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Doctoral Consortium

Edited By:

- Dr. Nour Elhouda DEHIMI
- Pr. Makhlouf DERDOUR
- Pr. Djamel BENMERZOUG
- Dr. Abdelkrim BOURAMOUL
- Dr. Mohammed Mounir BOUHAMED

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Preface

The first doctoral consortium comes with the fourth edition of the International Conference on Pattern Analysis and Intelligent Systems (PAIS'2022). This event was held on October 12-13, 2022, at the University of Oum ElBouagui, Algeria. The doctoral consortium of PAIS'2022 represents a real opportunity for Algerian Ph.D. students to deal with new challenges, share their different ideas, points of view, and solutions, and discuss future research trends. It represents the first successful national doctoral consortium in Algeria, and we are looking for future editions of this consortium. This proceeding contains the presented works in the doctoral consortium.

The PAIS 2022 Doctoral Consortium attracts Ph.D. students working on foundations, techniques, tools, and applications in the computer sciences and related fields. The doctoral consortium would like to become a significant point of contact between young researchers from Algeria and to share ideas and achievements in the theory and practice of artificial intelligence, data science, technology trends, control systems, networking, control systems, the internet of things, social innovation, etc. PAIS Doctoral Consortium aims to allow participants to present their research and discuss recent advances in the broad and quickly growing fields of Pattern Analysis and Intelligent Systems. The consortium also allows the participants to expand their professional contacts. We can proudly emphasize the number and origin of papers submitted to the consortium and the exceptional quality.

In this edition, PAIS Doctoral Consortium has received 50 papers. Each submission was reviewed in a rigorous process by at least two reviewers. The committee accepted 21 articles, with an acceptance rate of 42%. The authors of the submitted papers were from several Wilayas, including Constantine, Tebessa, Annaba, Oum Elbouagui, Setif, Souk Ahras, Khenchela, Oran, Algiers, ElOued, Bechar, Bejaia, etc. We want to take this opportunity to thank our sponsors for their valuable support: Oum Elbouagui University, the Faculty of exact science, natural and life sciences, and Easychair, LRS Laboratory, Annaba, Algeria. We also thank the rector of the Oum Elbouagui University, Prof. Zohir Dibi, and the Dean of the Faculty, Prof. Hebir Nacer. Our highest appreciations go to all who contributed to the success of this Consortium: reviewers, conference chairs, and the different committee members for their dedication and hard work.

October 13, 2022 **Dehimi nour el houda**
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An Approach to Cancer Prediction and Treatment Protocols with Radiomics and Artificial Intelligence in Radiology

Amira Bouamrane
dept. Mathematics and Computer Science (of L'arbi Ben M'hidi University
Oum el Bouaghi, Algeria
amira.bouamrane@univ-oeb.dz

Pr.Makhlouf Derdour
dept. Mathematics and Computer Science (of L'arbi Ben M'hidi University)
Oum el Bouaghi, Algeria
derdour.makhlouf@univ-oeb.dz

Pr.Ahmed Bouridane
dept. Computer Science
Centre for Data Analytics and Cybersecurity (CDAC)
Sharjah, UEA
a.bouridane@sharjah.ac.ae

Dr.Mohamed Amine Ferrag
dept. Computer Science (of 8 May 1954 University)
Guelma, Algeria
ferrag.mohamedamine@univ-guelma.dz

***Abstract*— Cancer disease is considered the most common cause of death globally, where the highest combined cancer rate for both men and women was 334.9 individuals per 100,000 in Denmark. Lung carcinoma is the most prevalent cancer type due to the delayed diagnosis, lack of precision, and difficulties selecting the most effective and appropriate treatment. Studies confirm that early nodule diagnosis can reduce the death rate. Nowadays, with the enormous success of artificial intelligence specifically, deep learning has had in the medical field, practical applications in radiology expand the use of AI and its techniques for cancer detection and treatment protocols.**

In this work, we intend to develop approaches based on artificial intelligence and its techniques, specifically the power of deep learning in radiology using 3D CNN to improve model accuracy, ensure lung cancer diagnosis, and determine treatment protocols, such as chemotherapy, hormone treatment, radiation therapy, or surgical intervention. To assess the efficacy and performance of the recommended approaches, we will use a local dataset of CT images from Ibn Rochd and Kaarer-sebti hospitals. As a result, the models will provide the following answers:

- **Is there a malignancy or not?**
- **What kind of lung nodule does the patient have?**
- **What is the appropriate therapy for this type of lung cancer?**
- **Is the patient's situation getting better**?

***Keywords*— *AI, Deep Learning, 3D CNN, radiomics, lung cancer, treatment, nodules, tumor, CT, screening*.**

I. Introduction

Cancer is malignant cells developed out of control that can attack healthy bodily tissues. When wounded or unrepaired cells resist dying, they develop into cancer cells and demonstrate unregulated proliferation and growth. Cancer cells frequently break away from the original clump of cells, migrate through the blood and lymph systems, and lodge in other organs, where the uncontrolled growth cycle can be repeated. The process through which cancer cells leave one place and expand in another is known as metastatic spread or metastasis. Lung cancer is the most frequent type of cancer worldwide, it begins with malignant cells developing in lung tissues, most commonly in the lining of the airways. People who are older and have a history of chest problems or lung illnesses such as emphysema is more prone to developing lung cancer. Furthermore, smoking is the first cause of lung cancer and the leading cause of cancer-related death worldwide [1].

The great success that artificial intelligence has gained using deep learning in image recognition in recent decades, particularly in medical imageries, has shown AI's potential to: reduce repetitive activities, boost report quality, execute challenging jobs such as screening, categorization, and comparison, and highlight information that is not apparent to the naked eye. Previous studies between 2010 and 2020 ensure that techniques such as deep learning and machine learning allow automatic characterization and classification of nodules with high precision and promise an advanced lung cancer screening method in the future [2]. In general, AI in cancer imaging can be used in two ways:

1) Radiomic features extracted from Region-of-Interests (ROIs) can be input into Machine learning methods for subsequent tasks.

2) An entire medical image or image series can be an input into deep learning (DL) model to perform the detection, characterizing, and monitoring of cancers [3]. DL distinguishes itself for its ability to extract features from tissue imagery and reduces radiologist effort while increasing accuracy, performance, sensitivity, and objectivity in a shorter time. In addition, when compared to traditional techniques such as machine learning, deep

learning ensures greater power and computational efficiency when dealing with complex tasks. Furthermore, the ability learn automatically feature representation without being explicitly identified by humans provides generalization ability, which improves diagnosis.

Research ensures that the lack of early cancer detection tools is one of the main reasons for this high mortality [4]. Lack of care, availability of specialists and specialized radiologists for remote and real-time diagnosis, and a scarcity of reliable databases for testing and training. We intend to combine artificial intelligence techniques, specifically deep learning using 3D CNN, with radiology to achieve the highest level of accuracy and performance for lung cancer diagnosis and classification, as well as to make treatment decisions as soon as possible and to allow doctors to assess the patient's health.

Most of the artificial intelligence applications in radiomics for lung cancer detection used different kinds of screening, MRI (Magnetic Resonance Imaging), CT (Computed Tomography), which used features extracted from several forms of images, PET (Positron Emission Tomography), Contrast-Enhanced Spectral Mammography differential diagnosis, and preoperative differentiation[5][6][7][8], and preoperative prediction with different techniques. However, not all lung tumours types are detectable using the same imaging technique. Small cell lung cancer is hard to diagnose due to its small size and location of the glands [9]. According to Titulaer et al. [10], in almost all patients (96%), the SCLC was found within one year of diagnosis. CT-thorax scans detected most of the tumors (93%) and were far more sensitive than chest x-ray (51%). A computed tomography (CT) scan is a three-dimensional data set with many slices that aids radiologists in identifying lung nodules. It can simultaneously capture bones and soft tissues and provide a more detailed visual representation. High-Resolution CT techniques developed in the last decade have become invaluable tools for detecting subtle diffuse lung disease patterns and their characterization of multiple possible diseases, and they provide detailed information [11]. Additionally, CT can detect tumors as small as 0.5 cm compared to a chest radiography, which detects tumors at 3 cm. Yet, it is important to note that smaller tumor size does not necessarily equate to an early stage cancer as each tumor has its own growth pattern and disease development [12]. Thakur et al. explain that 3D CNN is one of the best deep learning models for image segmentation and classification, and it performs better with 3D data [13]. While Bhattacharyya et al. proposed three CAD models using the LUNA 16 dataset, 3D CNN, 2D AlexNet, and 3D AlexNet, with experimental results indicating that the improved 3D-CNN archived accuracy of 97.17%, which is significantly higher than the two others [14]. A proposed method combined 3D CNN with Cross-Stage-Partial (CSP) achieved 95.3% sensitivity with 8 false positives per scan [15].

Another study used MIP images to detect lung nodules in CT scans. The combination of networks at various scales results in accurate and robust false positive reduction performance. When using CNNs to detect pulmonary lesions, especially small ones, MIP images can provide significant benefits. The proposed method achieves a sensitivity of 92.7% with 1 false positive per scan and a sensitivity of 94.2% with 2 false positives per scan [16].

- With this work, we want to build models using CT images and 3D CNN to predict, classify, and determine treatment protocols for lung cancer. We also want to generalize the proposed method to other cancer types, to demonstrate:

- Early diagnosis can reduce cancer's growing prevalence.

- Deep learning and machine learning have proven higher levels of intelligence and accuracy in diagnostic outcomes than humans have.

- Using a local database to ensure data quality.

- Allows patients and doctors to track the disease's evolution.

- Giving better precision in knowing the treatment of each diagnosed type of lung cancer and the effects of each therapy used.

The following challenges are expected to occur throughout this work:

- The smaller size of the available data, the quantity of datasets influences the task's quality, data augmentation can be used to increase the amount of data by warping, rotating, or inverting existing images, or creating synthetic data from existing using Generative Adversarial Networks (GANs) [3].

- Deep learning is a black box, what happens within and which features are the most effective are unknown. We may use a parameter to detect the beneficial elements as a solution.

- The recommended therapy varies based on the type of cancer found, where there are several multiple kinds of lung nodules, .e.g: Small cell lung cancer (SCLC), non-cell lung cancer (N-SCLC), squamous cell carcinoma (SCC), adenocarcinoma, and many more forms are examples.

- The difficulty of treatment selection, because of heterogeneity of imaging features and lung carcinoma histopathology. Tumor heterogeneity has presented a considerable challenge in matching patients with the right treatment at the right time[17], in this scenario, the integration of 3D CNN and CT 3D datasets can be a powerful tool.

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Cloud Native security Monitoring and prevention*

Amina Eldjou
LISIA Laboratory and NTIC Faculty, University of Constantine 2 - Abdelhamid Mehri
Constantine, Algeria
amina.eldjou@univ-constantine2.dz

***Abstract*—Cloud-native architecture is the emerging paradigm for IT services and providers such as AWS, Google Cloud, and Azure Microsoft. This paradigm is becoming a more attractive solution for large companies that want to eschew in-house servers. On the other hand, a breach in the security in any component in the cloud that has its security compromised might have unwanted consequences and the company's reputation be sullied. The purpose of our research can be represented two-fold, first, exploring the key challenges of implementing new cloud-native security solutions that provide an efficient and effective security posture, secondly, proposing a new approach to enhance the security of the cloud-native applications.**

***Index Terms*—cloud native, monitoring, security**

I. INTODUCTION

Cloud-based solutions are increasingly more attractive to businesses. By 2025, more than 85% of enterprises will adopt a cloud-first approach solution [1] these companies are required to deploy the cloud-native architectures in order to reach their expected revenues. Cloud-native technologies empower organizations to build and run scalable applications in modern and dynamic environments such as public, private, and hybrid clouds. Cloud-native deploys micro-services, a popular architectural style, built as a distributed set of small and independent services that interact through a shared fabric [2].

The success of deploying a microservices-based system into production depends on the following factors:

- Monitoring and health checks of the services and infrastructure [3].
- Scalable infrastructure for the cloud and orchestrators [4].
- Security design and implementation at multiple levels: authentication, authorization, secrets Management, secure communication [5].
- Rapid application delivery, usually with different teams focusing on different microservices at the same time.[6]
- DevOps and CI/CD practices and infrastructure[7].

A. Security issues

- The most common design pattern used in microservices is the API gateway style microservices Architecture [8]. Without a gateway, the microservices will be exposed to the "external world", making the attack surface larger. In addition to serving as a single point of access for all clients, API Gateway also functions as an edge service, exposing microservices as controlled APIs to the outside world. It contains additional responsibilities including load balancing, authentication and authorization, failure management, auditing, protocol translations, and routing[7]. Considering that it serves as the system's entry point, an API Gateway should always be a highly-available and effective component.
- Containers are small packages that include operating systems, application executables, and dependencies. One of these container components may be vulnerable. It is vital to have scanned and secure container images since they run on the scale of hundreds of instances in a standard Kubernetes cluster [9].
- Kubernetes designed to orchestrate cloud-native services [10], The main Kubernetes Security risk is Lack of Visibility. Visibility is essential for ensuring security. However, achieving visibility in complex, disrupted, containerized environments may be difficult.

B. Intrusion detection methods

To combat computer security risks, several intrusion detection methods have been proposed in the literature [11], which may be generally classified into:

- Signature-based Intrusion Detection Systems (SIDS): are based on pattern matching techniques to find a known attack
- Anomaly-based Intrusion Detection Systems (AIDS): In AIDS, a the normal model of the behavior of a computer system is created using machine learning, statistical-based or knowledge-based methods

II. RESEARCH PROBLEM

With increased adoption of Cloud and Cloud native solutions like Kubernetes, customers are facing new security challenges, they need to have better visibility of their cloud environments across different vendors such as AWS google and Azure Cloud and also other local cloud providers available in their countries. They also need to have visibility on the cloud-native solutions they are using, like containers run time Kubernetes and also DevOps solutions they are adopting.

Cloud Native Applications (CNA) are composed of many cooperating microservice instances that collaborate to achieve a common goal. For easy scalability. Every microservice is packaged into a container image and deployed as a container

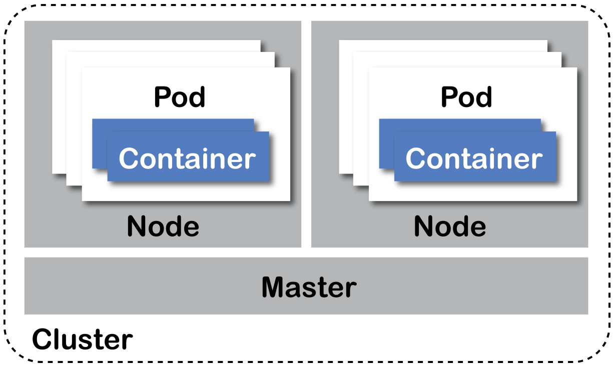

Fig. 1. kubernates architecture.

service, for quick scaling of container instances and orchestration tools like Kubernetes, Containers are a great enabler of cloud-native software. The Cloud Native Computing Foundation places microservice containerization as the first step in their Cloud-Native Trail Map [6]. The key components of Kubernetes are clusters, nodes, and the control plane. Clusters contain nodes. Each node comprises a set of at least one worker machine. The nodes host pods that contain components of the deployed application. The control plane controls cluster nodes and pods, which are generally distributed across several computers, to provide resiliency and high availability, fig. 1 shows the main component of CNA Architecture.

III. Outline of objectives

Almost all security challenges for cloud-native applications can be traced back to the nature of the cloud-native application itself. Monolithic application architectures are relatively static, while cloud-native application architectures are highly dynamic. The use of containers and serverless capabilities means that cloud applications are constantly shrinking and growing, moving between on-premises and off-premises [12], and even across multiple cloud platforms. This leads to many security challenges.

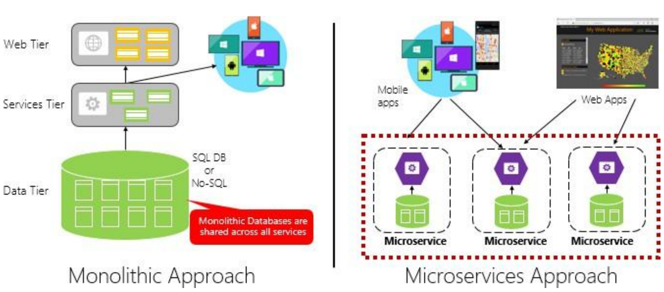

Fig. 2. Monolithic versus microservices architecture [6].

Fig. 2 illustrates the difference between a monolithic application approach and a microservices approach. Remain aware of how the monolith is made up of layered architecture that operates in a single process. It usually makes use of a relational database. However, the microservices method divides functionality into distinct services, each with its own logic, state, and data. Each microservice is responsible for its own datastore.

IV. Methodology and expected outcome

In this Ph.D. project, we will deploy different big data and cloud technologies such as Elasticsearch. The Elasticsearch Service is the official managed Elasticsearch offering on Amazon Web Services, Google Cloud, and Microsoft Azure[2], by building a robust architecture that will ensure the security of different components within a cloud system. Furthermore, the SIEM (security information events management) component of the elastic will be improved to handle more complex security situations based on artificial intelligence with real-time monitoring and detection[13]. Moreover, cloud-native architecture will be improved to deal with recent security threats, If the Cloud layer is vulnerable then there is no guarantee that the components built on top of this base are secure, The 4C's layers of Cloud Native security are Cloud, Clusters, Containers, and Code. Also Getting the right visibility and protection for cloud-native is the main challenge to improving security posture. The Monitoring Service is a mechanism to aggregate logs from different microservices and provides consistent reporting.

V. Acknowledgment

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6G Networks Security: Blockchain's current potentials and future prospects

Sabrina Sakraoui
dept. of Computer Science
Badji Mokhtar University
Annaba, Algeria
sabrina.sakraoui@gmail.com

Pr.Makhlouf Derdour
dept. Mathematics and Comp Sciences
L'arbi Ben M'hidi University
Oum el Bouaghi, Algeria
derdour.makhlouf@univ-oeb.dz

Dr. Ahmed Ahmim
dept. Mathematics and Comp Sciences
Mohamed Cherif MessaidiaUniversity
Souk Ahras, Algeria
derdour.makhlouf@univ-oeb.dz

***Abstract*—In this work, we provide an insightful summary of Blockchain-based security research for 6G networks. We start with a brief introduction to the topic. We also outline recent research under the concept of *wireless networks Blochainization*, while listing some research problems, possible solutions, and future directions.**

***Keywords* —Mobile Networks security, beyond 5G, 6G net- works security, Blockchain, privacy**

I. Introduction

Communication has always been a crucial element in the development of human civilization, relying on different as- pects, tools, and techniques, from the noise generated by vocal cords, through the exchange of letters via pigeons, up to data transmission via radio waves. It is worth mention- ing that the wireless communications industry is one of the industrial sectors that have experienced rapid expansion and breakthrough capabilities over the past few decades. Since Bell Labs' original development of the Advanced Mobile Phone System (AMPS) (i.e. 1G), there have been major and signifi- cant upgrades leading to the 2G, 3G, 4G, and 5G generation networks [1]. 5G has been promised to introduce various sophisticated features. However, some of these goals are currently far from being achieved. For example, the Internet of Everything (IoE) relies on enhanced broadband access for Machine-Type Communication (MTC), which is designed to make it possible for machines to interconnect wirelessly with no need for human involvement. However, it is beginning to be apparent already that some of the most critical requirements for MTC cannot be fully accommodated by 5G networks [2]. In addition, emerging application and land use scenarios on the horizon will introduce novel and more rigorous expectations from wireless connectivity. Next-generation wireless networks, specifically 6G, should consequently be flexible and highly efficient to address the various and complex requirementsexpected by 2030 [1].

Distributed ledger technologies, and primarily *Blockchain*, provide trustworthy associations between networked par- ties and eliminate the need for relying on intermediaries. Blockchain networks are designed as a decentralized peer- to-peer (P2P) environment that maintains a distributed and protected digital ledger. The underlying collaborative data structure consists of a series of blocks that are chronologically ordered. Each of these blocks contains a set of verified transactions, in addition to being cryptographically linked using signatures [3]. Blockchain is expected to be an important ingredient towards 6G [4]. For example, it can be crucial in supporting the realization of secure IoE solutions for 6G.

A. Research Problems, Motivations, and Objectives

6G can benefit from the security features provided by the Blockchain, such as immutability, transparency, and trace- ability. However, it is proven that Blockchain technology is only secure under certain predefined conditions and is also subject to cyberattacks (e.g., majority attacks) [5]. Worse, 6G adds to these threats, including inherited 5G threats, as each network generation remains in operation for years after the introduction of subsequent generations, e.g., in the case of 3G and 4G. In addition, backward compatibility is required to keep legacy devices in use connected. Therefore, 6G security is expected to inherit a fair amount of functionality from 5G [6]. Even worse, 6G also expands the scope for conducting sophisticated and timely attacks that exploit the introduced high throughput combined with instantaneous connectivity [2], another example of such vulnerabilities class can be found within the Network Intelligence (NI), which is based on Machine Learning (ML) and can be susceptible to a board range of attacks including adversarial examples.

The primary motivation for deciding how and when to patch or redesign security in a new generation is often security attacks that expose vulnerabilities in the underlying system or communication protocols. The conclusions drawn from se- curity attacks are useful in determining what progress has been made in a given system and how it can be improved. Future networks must use secure technologies to achieve superior efficiency and increased security, rather than being viewed as a double-edged sword; they must be highly protected against all types of attacks, or at least mitigate major risks, which is exactly what we intend to do within the context of our thesis. The main objectives are:

- To provide a holistic perspective on state-of-the-art Blockchain-based security and privacy mechanisms pro- posed for 5G/6G in recent years, and to provide a detailed analysis and the downsides of these mechanisms.
- To Highlight existing security and privacy issues in exist- ing network security propositions while enhancing both privacy and security by suggesting resilient Blockchain- based security architectures, protocols, and systems for future 6G networks.
- To investigate the validity and efficiency of smart Blockchain architectures for 6G networks security.
- To anticipate potential security and privacy concerns with future technologies significantly influencing 6G by surfacing eventual vulnerabilities alongside

Blockchain- based security solutions.

II. Blockchainizing Mobile Networks

Currently, research on security and privacy in 6G networks is still nascent, and existing efforts on these topics are mostly related to some upgrades in 5G networks [2], the use of a specific technology such as AI, IoT, and Blockchain [4]–[6], or scattered thoughts in high-level reviews of 6G conceptual designs [1]. An explanation for this can be seen underlying the fact that the core network components of 6G are largely undefined. Blockchains are expected to be collaboratively adopted and integrated into 6G across multiple network do- mains, including core, transport, edge, and access networks, further supporting a sophisticated 6G ecosystem that offers a wide range of new and enhanced services and applications, this paradigm is referred to as Blockchainized 6G [7]. Broadly speaking, this paradigm is composed of two classes as follows:

1) *Infrastructure-based Security Services:* In this class, the Blockchain is considered to be part of the 6G infrastructure. In other words, the functionality provided by the Blockchain is required within the background structure of the network, in- cluding access control, secure spectrum management, content caching, network architecture decentralization, interference management, privacy compliance, secure dynamic network slicing, dynamic agreements, roaming, context-awareness, of- floading, public-key infrastructure, etc [1], [4], [6], [7].

2) *Applications-related Security Services:* In this class, Blockchain is considered as a security support for futuristic 6G applications, while this was already available in previous gen- erations (4G, 5G), however, futuristic applications require high efficiency from the underlying network. This includes reliable decentralized ML, sophisticated IoE middleware platforms, securing future extended/virtual/augmented reality apps, and smart contracts-based trust-free trading [4], [7].

III. Open Challenges, Possible Solutions, and Future Directions

Some see Blockchain as the Swiss army knife for safe- guarding integrity in decentralized 6G environments. How- ever, at the current maturity of the existing Blockchains, this presumption is quite optimistic. Attacks on mobile networks with millions of subscribers are considered a threat to national security. 2G and 3G offered a good showcase of how attackers leveraged unencrypted identity credentials in authentication and paging mechanisms to track mobile subscribers [6]. It is a major challenge to deal with the *inherited security and privacy issues* **(C1)**[1] of older mobile network generations alongside the new issues of future technologies and protocols. Furthermore, Blockchain is not invincible against cyberattacks. In fact, it has two vast vulnerability categories, firstly core- oriented, including sybil attacks, stress testing, timejacking, and 51% attacks. Secondly, client-oriented, including wallet theft, selfish mining, smart contracts manipulation, and double spending attacks [5]. Another challenge for this pair would be the *incredible speed required from the Blockchain* **(C2)** to keep up with 6G, as the network is expected to support speeds beyond 1TBit/s (x50>5G), with latency projected at most 100μs. The consensus mechanism, on the other hand, re- quires significant on-site processing with checks, suggestions, and associated cryptographic challenges; not to mention the significant network overhead to establish it. All of this can have a serious impact on the network and actually affect its real-time security.

Patching vulnerable systems **(S1)** in older network gener- ations is a must, and for newer systems, the design concept must introduce security in the early stages of the design, not at the end or, worse, after the fact. Blockchain must be deployed in a way that enhances 6G security, not increases the threat. This can be ensured by introducing *security intelligence* **(S2)** into the Blockchain in a safe and efficient manner. In addition, *lightweight and highly secure consensus* **(S3)** mechanisms must be developed and implemented if 6G network providers intend to preserve Blockchain's security features within the network infrastructure.

Blockchain is emerging as a new enabler for *decentralized learning* **(D1)** approaches such as Federated Leaning (FL). This involves storing model updates within the Blockchain. However, there will be a trade-off between privacy and performance. This is currently and will continue to be an important research direction. In the long term, Quantum- safe cryptography will be a necessity, which also implies approaches for *Quantum-safe Blockchains* **(D2)** for 6G.

[1] **C: Challenge; S: Solution; D: Direction**

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Bio-inspired approaches for IoT System Control

KAMOUKH Ahmed
Department of Mathematics & Computer Science,
University of Oum El-Bouaghi, Algeria
ahmedkemoukh@gmail.com

ZERTAL Soumia
Department of Mathematics & Computer Science,
University of Oum El Bouaghi , Algeria
szertal@gmail.com
https://orcid.org/0000-0003-0127-900X

CHABOUT Samira
Department of Mathematics & Computer Science,
University of Oum El Bouaghi, Algeria
chebbout_info@yahoo.fr

Abstract—**The aim of this paper is to give an outline about the research-works carried out as part of my doctoral thesis. The overall objective is to propose a novel approach based on IA techniques to provide a control in IoT system. For this, we first present the IoT architecture. Next, we focus on the QoS factor in the IoT architecture. Finally, we highlight some existing IoT architectures, which use intelligence artificial and bio-inspired architecture to improve QoS.**

Keywords—IoT System, QoS, architecture IoT, Bio-inspired algorithm, system control. Deep learning, Edge computing, Fog computing

I. Introduction

The Internet of Tings (IoT) is paradigm that enables the communication between wide variety of sources such as devises and home appliances, surveillance cameras, monitoring sensors, actuators, displays, vehicles, through the internet in order to facilitate life mode. IoT is progressively becoming an important aspect of our life that can be sensed everywhere around us. But the amount of data generated from the interaction of different elements of an IoT system is enormous, the resources and limited storage and processing capacities of the objects are unable to manage and process this quantity of data. this need for storage and processing of large masses of data is supported by the computing infrastructure through the cloud. Currently, the limited capacity of the internet to transmit and process this amount of information is a major problem. Therefore, consistent and timely treatment becomes a strong necessity.

The development of these IoT systems has now become increasingly attractive and interesting given:

The development of new wireless network technologies and the appearance of promising new paradigms such as Edge Computing, Fog Computing and 6G.

The appearance of artificial intelligence of objects (AIoT), which is the result of combining the power of artificial intelligence, computing power and the infrastructure of the IoT.

To provide a better-quality service in an IoT system, it is necessary to explore and analyze more efficient IoT architectures which ensure a good control of the operation of the IoT system. These architectures are based on AI techniques and exploit new technologies such as Edge Computing and Fog Computing.

II. IoT Architectures

The IoT architecture consists of important layers that defines all the functionalities of IoT systems. Currently [1], there are two layered based IoT architectures which has been proposed, 3-Layered architecture and 5-Layered architecture. The IoT architectures can be modified according to the need and application domain [1].

A. Model 3-layered

The Perception Layer, The Network Layer, The Application Layer [2].

B. Model 5-layered

The Perception Layer, The Transport Layer, The Processing Layer, The Application Layer, and The Business Layer [2].

a) *The Perception Layer:* This is the first layer of IoT architecture. In the perception layer, RFID tags GPS, camera, sensors, sensor network and terminals. Its primary goal is to recognize the entity and information collection [2].

b) *The Network Layer:* As the name suggests, it is the connecting layer between perception and processing layer. It gets data from perception layer and passes data to middleware layer using networking technologies like 3G, 4G,5G, UTMS, WiFI, etc [2].

c) *The Processing Layer:* Processing Layer has some advanced features like database management, cloud computing, smart processing, ubiquitous computing and action taking capabilities [2].

d) *The Application Layer:* The responsibility of the Application Layer depends on the data processed at the Processing Layer and to develop diverse applications of the IoT. This includes smart transportation, logistics administration, uniqueness authentication, location-based service (LBS) and safety etc. This layer offers applications for every kind of industrial usage and also to promote the IoT development to a larger scale development [2].

e) *Business Layer:* The business layer performs the managing task that includes management of applications and business model. The success of any device does not depend only on technologies used in it but also how it is being delivered to its consumers. Business layer does these tasks for the device. It involves making flowcharts, graphs, analysis of results, and how device can be improved, etc. [2].

III. Quality of Service (QoS)

The latest forecasts have predicted that there will be between 26 and 50 billion connected devices which are potentially resource-constrained and/or mobile has led to quality of service (QoS) concerns [4]. It is important to know if QoS has been addressed at all layers of the IoT architecture, in order to ensure smarter IoT ecosystem fulfill the requirements of QoS standards. Also, to ensure the reliability of any IoT service and device, its QoS metrics must be defined first. There are certain good quality models available in literature such as ISO/IEC25010 and OASIS-WSQM [1].

IV. Emerging Cloud Computing

The idea of emerging cloud computing was developed to provide solutions to the challenges of the traditional cloud computing. It tries to bring computation much closer to the users by adding a layer between the cloud and the users (Fog computing, edge computing, serverless computing, volunteer computing, and software defined computing). The aim is to improve QoS. Processing of data generated by user devices is done at the edge of the network in place of being transferred to the far away cloud data center. This reduces band width and amount of energy consumed. There are different projects where researchers applied deep learning algorithms to solve problem in emerging cloud computing architecture (see Fig. 2.).

Although, there are several reference architectures proposed and use emerging cloud computing, but these are still far from the standard architecture that is suitable for global IoT. A suitable architecture is still needing to be designed that could satisfy the global IoT needs. Finally, they gave another solution example: Logic bio-inspired techniques. These bio-inspired algorithms such: evolution, ants, swarm, ecology, network, immune can overcome IoT challenges example:

- Integrating bio-inspired solutions to tackles the issues of mobile sensors in MWSNs for IoT [6].

- Threshold Model (RTM): RTM is inspired from decentralized insect colonies. RTM is mapped to the service discovery and selection problem in IoT settings [7].

- Searching and selecting the appropriate sensors for a query with minimal time consumption and a high quality, that mimics the bubble-net hunting and foraging behavior of a humpback whale [8].

V. Conclusion

The aim of this short-paper was to present our global objective, which consists to propose a novel approach based on IA techniques to provide a control in IoT system. To do so, we have first presented the models of IoT architecture and the importance of QoS factor in the IoT system. Then, we have highlighted some existing works, which focus to improve the QoS value by using the bio-inspired approaches and artificial intelligence.

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A based Semantic Deep Learning approach for cancer diagnosis

1st Ramzi Agaba
ReLa(CS)2 Laboratory
University Larbi Ben Mhidi
Oum El Bouaghi, Algeria
ramzi.agaba@univ-oeb.dz

2nd Rohallah Benaboud
ReLa(CS)2 Laboratory
University Larbi Ben Mhidi
Oum El Bouaghi, Algeria
r_benaboud@yahoo.fr

***Abstract*—Cancer is one of the worst and most dangerous diseases facing humans and all living beings, it is basically an uncontrolled cell growth that can lead in severe cases to death, these cells will divide and grow, which results either shaping some malignant tumors invading the nearest organs, taking over the body and bringing it to the most vulnerable state, consequently dragging the ill to a devastating physical and psychological condition, on the other hand, there are benign tumors that are not cancerous, they also do not have the same properties as the latter, they do not actually invade other tissues and other parts of the body. Thus, diagnosing early-stage cancer may create a chance and some room for basic and personalized treatments, that can preserve one's life. Several methods were brought to the table for the same goal, aiming to improve and enhance the field of healthcare. Inspired by the success of deep learning and semantic data mining, we seek to integrate data semantics into the process of deep learning, which inherently would make a new approach that can positively affect and influence cancer diagnosis and fasten the process of the procedures that are usually integrated to tackle such a phenomenon.**

***Index Terms*—Artificial Intelligence, Medical Diagnosis, Cancer, Deep Learning, Semantic Data Mining, Ontologies**

I. Introduction

Artificial Intelligence is involved and used in every industry, in healthcare it is used to detect and predict cancerous tumors, in supply factors to detect and find positive or negative causes and aspects that influence the business, and in financial services to predict changes and identify opportunities to allow investors to know when to buy, sell or trade their investments. The field of healthcare has great importance because of its broad spectrum of reach for individuals and communities, and the wide range that it covers. Health is one of the main concerns of machine, deep learning researchers, and industry experts due to its high volume and veracity of data [1].

II. Research problem

The past decade has seen great advances in artificial intelligence techniques applied to all domains. Several of those techniques have been proposed to help diagnose and solve problems related to human health, particularly in the healthcare domain. Artificial intelligence is used to improve the speed and accuracy of disease diagnosis, facilitate clinical care, moreover, enhance health research, and drug development, furthermore, support a variety of public health interventions, such as disease surveillance, outbreak response, and health systems management. On the same stream, one of the most common and interesting applications is mainly done on the early-stage cancer diagnosis [2] [3], one thing to clarify is that cancer is primarily not a single disease, it is more like a collection of diseases known for uncontrolled growth and abnormal spread of cancerous cells. If that spread is not controlled at a certain time, it can lead to death [4]. Figure 1 shows the difference between normal and cancerous cells [4]. These cells differentiate in many measurable factors which makes them identifiable. Cancer can be triggered by many factors both external and internal, the external ones could be any of the following: tobacco, chemicals, infectious organisms, and radiation, nevertheless the internal ones are mostly inherited mutations and hormones. These causing factors can work together leading to create and initiate cancer. One way to tackle the problem of cancer is radiation, the other ways to get rid of cancerous cells are chemotherapy, hormone therapy, biological therapy, and targeted therapy surgery [4].

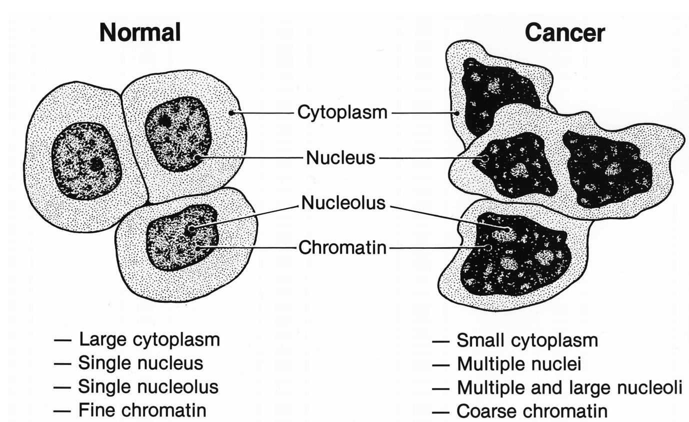

Fig. 1. The Difference between Normal and Cancerous Cells (from [4])

One other thing worth mentioning is that cancer stages are essentially the extension and the growth of the main cancerous tumor at the time of diagnosis. Correct and accurate cancer staging is necessary and crucial to determine the most suitable therapy and to shed light on all the other possibilities for the treatment [4].

III. Outline of objectives

Deep learning models are data-dependent. In other words, data is crucial for the latter, Deep learning models practically require a lot of data to create a better and more efficient models. What also comes with this circumstance is that with this vast volume of data that needs to be gathered and put together, a problem may arise. The main reason behind the problem occurrence is the veracity of data structures available and the heterogeneity of each data source. Methods were put together to overcome that problem, one of the basic approaches is integrating any of the forms of data semantics, either using semantic ontologies, knowledge graphs or other semantic forms into the deep learning process which makes it easier for the algorithm to read different data structures and comprehend it in a better way. Knowledge is the formal understanding of different objects. Inspired by the Human knowledge and its ability to solve different tasks easily. Knowledge graphs are a representation of the structural relations between entities [5], it is inspired by human problem solving and its goal is to allow systems to gain the ability to solve different and complex tasks [6]. Deep learning is commonly known as a set of machine learning methods that attempt to model data representations through many layers of nonlinear transformations, deep learning is not only an improvement of machine learning algorithms but also a new sector in artificial intelligence research. The idea of the artificial neural networks arises from our comprehension of the human brain and the way it works, which mainly uses connections between neurons. The difference between artificial neural networks and the human brain cells is that all human brain neurons are connected to each other via a physical path, artificial neural networks contain discrete layers and connections instead [7]. In addition, knowledge engineering research has often focused on modeling high-level human cognitive abilities, such as reasoning, inference, and validation. One other thing deserves mentioning is that formal knowledge or ontologies integration facilitates the reuse and the share of data and results in a machine-processable way. It also fosters many advances in the field of artificial intelligence in general, which refers to data mining tasks that systematically integrate ontologies, in particular formal semantics, into the data mining process Computer scientists believe that domain ontologies can play a crucial part in improving data-mining processes to uncover knowledge from dataset more effectively. Ontology is a representational model of knowledge common to a specific area of expertise or knowledge domain that provides an explicit description of conceptualizations. The knowledge in an ontology is represented in a hierarchical structure that consists of concepts and the relationships between them [8] [9].

IV. Methodology and expected outcome

Recent studies indicated that knowledge discovery (knowledge semantics) can positively influence all stages of data mining and machine learning processes [10]. Semantics can fundamentally promote the performance of data mining in many aspects. It can bridge and tunnel the semantic gap between data, applications, data mining algorithms, and data mining results. Using ontologies can also provide data mining algorithms with a priori knowledge that guides the mining process or reduces and constrains the search field. Furthermore, the effectiveness of ontologies in data mining has been documented in several previous research works, both in empirical and theoretical studies. It was shown that ontologies can bridge the semantic gap through semantic conscious preprocessing and annotation of semantic data [11] [12] [13]. Due to all the previous revelations and the successful impact of merging both deep learning and data semantics, our main quest and goal is based on the idea that the different forms of data semantics (ontologies, knowledge representations...) have the ability and the potential to support and help the process of deep learning, which consequently can have a significant influence on the results of all the fields; to be precise the field of healthcare in medical diagnosis. The work consists of detecting and finding a new approach that integrates data semantics with the deep learning process for cancerous tumor identification or cancer diagnosis.

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Testing Multi-Agent Systems Using the Mutation Analysis Technique

1st Soufiene Boukelloul
Department of Mathematics and Computer Science
University of Oum El Bouaghi
Oum El Bouaghi, Algeria
soufiene.boukelloul@univ-oeb.dz

2nd Nour El Houda Dehimi
Department of Mathematics and Computer Science
University of Oum El Bouaghi
Oum El Bouaghi, Algeria
dehimi.nourelhouda@univ-oeb.dz

***Abstract*—Multi-agent systems (MAS) present distinct challenges for software verification due to their autonomous, distributed, and interactive nature. This paper explores the application of mutation analysis as a systematic methodology for evaluating the efficacy of test suites in detecting faults within MAS. By introducing syntactic alterations into the agent code- base, mutation testing provides quantitative metrics for test suite adequacy. The proposed approach facilitates the identification of insufficient test coverage and enhances the overall reliability of agent-oriented systems. Experimental validation demonstrates the effectiveness of mutation-based assessment in improving test suite quality for complex multi-agent architectures.**

***Index Terms*—Multi-Agent Systems, System Level Testing, Mutation Analysis, Test Adequacy, Software Verification**

I. Introduction

The proliferation of autonomous software agents in critical domains necessitates robust testing methodologies to ensure system reliability and correctness [1], [2], [3]. Traditional testing paradigms often prove inadequate for multi-agent systems due to emergent behaviors, non-deterministic interactions, and decentralized control structures. Mutation analysis offers a promising avenue for assessing test suite effectiveness by sim- ulating potential faults through controlled code modifications. This paper investigates the adaptation of mutation testing techniques to the unique characteristics of MAS, addressing challenges such as agent communication, goal-oriented behaviors, and environmental interactions [4], [5], [6], [7]. The research contributes to the broader objective of establishing standardized verification practices for agent-based software engineering.

II. Related Work

Previous research has explored various testing strategies for MAS, ranging from unit-level verification to system-level validation. Zhang et al. [8] introduced automated unit testing frameworks specifically designed for agent systems. Nguyen et al. [9] extended this through goal-oriented testing methodologies that align test cases with agent intentions. Mutation testing, originally developed for conventional software, has seen limited application in MAS contexts. Savarinouthi and Winkoff [10] defined mutation operators for goal-agent languages, while Huang et al. [11] applied mutation testing to Jason agents. Our work builds upon these foundations by proposing a comprehensive mutation analysis framework tailored for heterogeneous multi-agent architectures [12], [13], [14].

III. Methodology

The proposed mutation analysis framework consists of three primary phases: mutant generation, test execution, and adequacy evaluation. Mutants are created by applying a set of mutation operators specifically designed for agent-oriented constructs, including belief modifications, plan alterations, and communication perturbation. The operator set encompasses both general-purpose mutations (e.g., arithmetic operator replacement) and agent-specific mutations (e.g., goal precondition modification).

A. Mutant Generation

Let A represent an agent program and M denote the set of mutation operators. For each operator $m_i \in M$, a set of mutants A'_i is generated:

$$A'_i = \{m_i(a) | a \in \text{fragments}(A)\}$$

where fragments(A) denotes syntactically valid code segments susceptible to mutation.

B. Test Execution

Each mutant is executed against the test suite T. A mutant is considered *killed* if at least one test $t \in T$ produces divergent output compared to the original program. The mutation score MS is computed as:

$$MS = \frac{\text{number of killed mutants}}{\text{total mutants}} \times 100\%$$

C. Adequacy Criteria

A test suite is deemed adequate if it achieves a mutation score exceeding a predefined threshold τ, typically set at 90% based on empirical studies. Scores below τ indicate insufficient fault detection capability, necessitating test suite augmentation.

IV. Experimental Setup

The evaluation employed three distinct MAS implementations: an e-commerce negotiation system, a distributed sensor network, and a cooperative robotics simulation. Each system was instrumented with mutation operators using a custom extension of the MuJava framework. Test suites of varying coverage levels were applied, and mutation scores were calculated for comparative analysis.

V. Results

Experimental results demonstrate a strong correlation between mutation scores and actual fault detection rates. Test suites achieving $MS \geq 90\%$ successfully identified 94% of manually seeded faults, while suites with $MS \leq 70\%$ detected only 58% of faults. Table I summarizes the findings across the three test systems.

TABLE I
Mutation Scores and Fault Detection Rates

System	Test Suite Size	Mutation Score	Fault Detection
E-commerce	156	92%	95%
Sensor Network	203	88%	91%
Robotics	187	94%	96%

VI. Discussion

The mutation analysis approach effectively quantifies test suite adequacy for MAS, providing actionable metrics for test improvement. However, several challenges emerged during experimentation. Equivalent mutants—those that produce behaviorally identical outputs despite syntactic differences—remain difficult to detect automatically. Additionally, the computational overhead of mutant execution grows substantially with system complexity. Future work should investigate heuristic approaches for equivalent mutant identification and parallel execution strategies to mitigate performance concerns.

VII. Conclusion

Mutation analysis represents a valuable technique for assessing test suite effectiveness in multi-agent systems. By adapting mutation operators to agent-specific constructs and establishing quantitative adequacy thresholds, developers can systematically improve test coverage and fault detection capability. This research demonstrates the practical applicability of mutation testing to MAS validation and provides a foundation for more comprehensive verification frameworks in agent-oriented software engineering.

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Artificial Intelligence and Medical Decision Support Systems

Asma Merabet
Department of Computer science
University of Oum El Bouaghi
Oum El Bouaghi, Algeria
asma.merabet@univ-oeb.dz

Asma Saighi
Department of Computer science
University of Oum El Bouaghi
Oum El Bouaghi, Algeria
pgasma_saighi@yahoo.fr

Zakaria Laboudi
Department of Computer science
University of Oum El Bouaghi
Oum El Bouaghi, Algeria
laboudi.zakaria@univ-oeb.dz

***Abstract*—Artificial intelligence has an effective and important impact in our daily life, especially in the medical field. In this perspective we present in this paper a brief overview about the integration of Artificial Intelligence in the medical sector to help medical decision makers and healthcare systems improve their approache.**

***Index Terms*—Artificial Intelligence , Machine Learning, Deep Learning , Medical decision support system**

I. Introduction

Medical diagnosis is a complex process as it relies on the doctor's reasoning ability to recognize the symptoms. This step is particularly complicated due to the information used, which may be incomplete and could be tainted by uncertainty and other forms of imperfection. Due to the progress of IT(Information Technology) and the collection of patient information in a systematic process, several new medical tools have been developed to guide doctors in the decision making process to take intelligent decisions. and others to provide an intelligent decision support system for the patient's care. Some of these tools are used to assist the doctors in their decisions. Indeed, "decision support systems"or "expert systems" can be used for diagnostics to assist doctors in the elaboration of their prescription of therapies [2]. In this work, we review a state of the art about the use of AI in medical decision support systems.

II. Artificial Intelligence in Medicine Field

Artificial intelligence (AI) describes the use of machines and techniques to simulate intelligent operation and human-like thinking [2]. Nowadays, AI is becoming part of our daily life in different forms, including personal assistants (Siri, Alexa, Google assis- tant, etc.), as well as automated public transportation, aviation and video games. And more recently, AI has also started to be embedded in medicine for better patient care. [3]
Artificial intelligence in healthcare can provide medical decision support for doctors, as well as help to increase the autonomy of diabetic patients for example. On another side, data analytic techniques can detect pathology, and avoid having patients subjected to invasive examinations, as Thibault Pironneau explains [4].

AI provide doctors the opportunity to earn time by allowing the machine itself to analyze and provide estimates, In such a way, doctors may intervene quikely and succesfuly.

The use of AI in the medical imaging field was proposed to increase the accuracy, coherence and efficiency of reported data. It provides the possibility to identify lesions, perform diagnostic tests and produce automated medical reports [5].

III. Medical decision support system

The automation of data-based medical diagnostic modeling can provide clinical decision support and enhance the efficacy of health care delivery in the clinical settings [7]. Many definitions regarding Medical Diagnostic Decision Support Systems have been suggested, among others: A medical decision support system is an organized collection of information, to assist the clinician in his/her reasoning to identify a diagnostic and choose the adequate therapy, establishing a conversation between man and the machine [6]. Medical decision support systems (MDSS) are software programs that provide clinicians with timely and relevant information about a patient's clinical situation. a clinical situation of a patient as well as the appropriate information for that situation, properly situation, correctly screened and displayed in such a way to improve quality of patient health care and health of patients [6] .

IV. Related Work

Due to the importance of AI and medical decision support systems nowadays, several researchers have focused their research towards this domain [8].
A useful decision-making system has been proposed for classifying community members and thereby for managing demand and monitoring disease outbreaks across the

healthcare supply network. In the proposed approach which based on physicians' knowledge and fuzzy inference system , the users are first grouped according to two criteria, age range and pre-existing diseases (such as diabetes, heart problems or high blood pressure). These users are then classified using the FIS (Fuzzy Interface System). In this approach, both input and output variables are not linear; therefore, the FIS approach enables the appropriate functions (rules) to be determined for different conditions. The health care chain suggested in this study is a two-tiered chain, including community members (service recipients) and the health system (service providers). Within this supply chain, the healthcare equipment and services provided by the healthcare system are considered to be the product [8].

Another approach consist of proposing an IoT-based fog calculation model to diagnose patients who have suffered from type 2 diabetes [9]. The system is applied for type 2 diabetes monitoring and surveillance for patients and repeated examinations automatically. This work has three major layers: cloud layer, fog and wearable IoT sensors. the researchers proposed a novel system which is established on WBAN for the wireless transmission characteristics, which are able to classify the gaps of conventional systems. The proposed system is composed of the following components: The main core of the proposed healthcare model is the WBAN or medical sensor node. It consists of a collection of various physical devices containing hand-carried sensors which have been combined along with a small wireless module to collect data that helps physicians identify type 2 diabetes disease in the early stages. These sensors comprise key biologic data such as blood pressure. There are the smart e-health gateways on IoT devices fully responsible for managing and collecting geographically distributed patient data. After the use of apps and mobile devices from the collected patient data, the patient information can be summarized, for example, by the generation of patient identifiers in the system. The data extracted from the WBAN conveyor is delivered to the crowd via WiFi and stored in the cloud for processing and dissemination. Then, consultants and physicians are able to determine the severity of patients' type 2 diabetes through the N-MCDM model [9].

Also, Parthiban and Srivatsa in [10] proposed a machine learning algorithm for detection and analysis of heart disease utilizing Naive Bayes algorithm which provides 74% , Support vector machine. Other researchers proposed a cloud-based IoT with a clinical decision support system for CKD (Chronic Kidney Disease) prediction and adherence with its severity level. The frame- work proposes collects patient data through IoT devices at- tached to the user to be stored in the cloud with associated medical records from the UCI repository. In addition, They used a Deep Neural Network (DNN) classifier for the predic- tion of CKD and its severity level [11]. To estimate the DNN classifier's classification results on the applied CKD dataset, a set of experiments is performed. The suggested model has been implemented by employing Python programming and Amazon Web Services (AWS). For experimentation, the parameter used is batch size: 8, learning rate: 0.02, epoch or step size: 10000, score threshold:0.7, minimum dimension: 600 and maximum dimension: 1024 [11].

In another study , researchers have focused on the duration of hospital stay in two major services: the cardio service and the surgery service. Concerning the cardio service, a study that is led by (Lafaro et al., 2015), 8 variables were selected among 36 to design the DDS prediction model [12].

However, The previousely presented systems has some limits such as the security of patient data and the effectiveness of the learning model.

V. Conclusion

In this paper, we presented the problem statement, the methods used and the advantages of AI in the medical field in order to support medical decisions. As future orientations, we intend to conduct extra research for intelligent medical support systems to reduce the limitations of previous research to provide a more secure and robust medical support system.

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Bio-inspired and Artificial Intelligence Based Approaches For Internet of Things Security : Challenges and Opportunities

1st Imed Eddine BOURAMOUL
Department of Mathematics and Computer Sciences
Faculty of Exact Sciences, Natural and Life Sciences
Larbi Ben M'hidi University
Oum El Bouaghi, Algeria
imededdine.bouramoul@univ-oeb.dz

2nd Soumia ZERTAL
Department of Mathematics and Computer Sciences
Faculty of Exact Sciences, Natural and Life Sciences
Larbi Ben M'hidi University
Oum El Bouaghi, Algeria
szertal@gmail.com

3rd Makhlouf DERDOUR
Department of Mathematics and Computer Sciences
Faculty of Exact Sciences, Natural and Life Sciences
Larbi Ben M'hidi University
Oum El Bouaghi, Algeria
derdour.makhlouf@univ-oeb.dz

***Abstract*—The Internet of Things describes a network of physical objects equipped with sensors that exchange data via the Internet network. IoT security is the field that concerns the protection of connected devices and networks in such systems. It has become the subject of intense scrutiny in recent scientific work, and has attracted more and more interest from researchers in this field. Indeed, problems related to authentication, confidentiality and data integrity are the major concerns of security in IoT systems. The work presented in this paper falls within this context and aims to highlight three important security aspects, namely: the challenges of IoT security, the use of bio-inspired approaches to solve security problems, and the integration of Artificial Intelligence and Machine Learning techniques to offer more reliable and efficient security solutions. More precisely, in this paper, the security challenges of IoT systems related to the limit of resources, complexity and mobility to ensure the interconnection between objects have been explored and a categorization by application field of the latter has been proposed.**

Keywords— Bio-inspired Approaches, Artificial Immune Systems, Artificial Intelligence, Machine Learning, IoT Security

I. Introduction

Security is a problem whose solution is a complex process that requires the interaction of several organizational, technical and legal factors. This problem becomes even more complex in Internet Of Thing (IoT) systems, this complexity is mainly caused by the particularity of IoT systems, especially in terms of the absence of a reference model and the resources limitation. In this context, the use of bio-inspired approaches, especially those based on Artificial Immune Systems (AIS) for the security of an IoT system, is a promising solution that is needed.

Indeed, AIS are a new metaphor inspired by human defense mechanisms that are characterized by a massive and parallel distribution as well as a highly reactive and evolutionary adaptation. Furthermore,[1]. IoT systems are also characterized by the fact that they have a massive distribution, that they are mobile, dynamic and complex and that they are scalable in space and time [2].

A summary of the characteristics related to AIS and those related to IoT systems shows that the two systems are strongly aligned. A security approach for IoT systems inspired by SIA systems is therefore a solution that has definite potential [3]. To this end, a study of security challenges as well as those of AIS and Artificial Intelligence (AI) techniques for IoT security will be discussed in the rest of this article.

II. Application Field and Security Challenge of IoT

Nowadays, the Internet of Things is considered as the third industrial revolution [4]. It is defined as "the interconnection, via the Internet, of computer devices embedded in everyday objects, allowing them to transmit and receive data" [5]. The most common uses of IoT are smart home and connected, smart grids, smart connected health, connected vehicles and industrial IoT, etc.

Security risks related to connected objects affect not only the security of IoT systems, but also the entire ecosystem, including websites, applications, social networks and servers [6]. According to [7], security attacks are problematic for the IoT due to the following factors:

1. Objects have a limited capacity in terms of resources.
2. The objects (actuators and sensors) are physically accessible.
3. Objects evolve in open systems, and are controlled via wireless connections, which makes them vulnerable to attacks.

Furthermore, IoT systems are used in several areas, and therefore pose different challenges in terms of security. A synthesis of the work presented by [6]-[14], allowed us to identify the most common areas of application of IoT-based solutions as well as the challenges of each area. They will be presented in the following section:

1. Medical applications: IoT is used in remote monitoring of medical applications using smart sensors. In this area, the most important challenge is that of confidentiality and unauthorized access.
2. Military applications: This area uses the IoT in disaster relief, battlefield communication, and military

equipment tracking. The objective in this area is to ensure the security and reliability of communication.

3. Industrial applications: Manufacturing control, smart meters, automation and motion control are also application areas of IoT. The major security challenge is to ensure interoperability, analysis and data transfer.
4. Automotive Applications: In this field, the IoT is used to reduce traffic jams, control parking, avoid traffic accidents and spot drunk drivers. Among the security challenges is keeping personally identifiable information from vehicle systems confidential.
5. Environmental Applications: Applications are geared towards waste management, water management, animal tracking, weather monitoring and forecasting, and environmental protection. The objective here is to ensure the integrity of the data during their transfer
6. Agriculture Applications: IoT systems are used for soil analysis, precision farming, agricultural drones, and livestock monitoring and smart greenhouses. The integrity and speed of data analysis to avoid agricultural crop losses are the challenge in this area.
7. Consumer Applications: In this field, many consumer applications based on IoT technology are available, such as connected homes, connected cars. Security concerns are related to information security and confidentiality.

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III. Artificial Immune Systems for IoT Security, concepts and relevant Works

Bio-inspiration is a shift paradigm that has led researchers to draw inspiration from nature to develop new systems in various fields. Bio-inspiration is often based on biomimicry, which is an interdisciplinary creative process between biology and technology [1]. As in the case of biomimetics, bio-inspiration takes its inspiration from the world of plants, animals or that of bacteria and viruses.

Artificial Immune Systems are adaptive systems inspired by biological immune models, they are mainly applied to solving science and engineering problems. Several works based on AIS for IoT security have been proposed, we quote in this context the most relevant of them : [15] proposes a defense framework for IoT security based on AIS to solve the problems of static defense strategies, the proposed approach adopts a dynamic and circular defense which consists of five layers. Similarly, [16] proposes an adaptive immunity system which consists of creating a virtual layer implemented in the core of the system, the proposal uses mobile agents and their characteristics of self-adaptation, self-defense and self-monitoring. [17] describes a model inspired by biological processes to ensure security in a mobile ad hoc network, the proposed model uses the characteristics of AIS including imperfect detection, anomaly detection and adaptive detection to secure ad hoc networks. Finally, [18] uses Machine Learning techniques to differentiate between legitimate and fraudulent nodes in a wireless network. It starts from an inspiration based on the human immune system to use virtual antibodies in the system to deactivate fraudulent nodes.

IV. Artificial Intelligence techniques for IoT security

The evolution, complexity and diversity of attacks targeting the security of IoT systems have forced researchers to orient their solution to the use of Artificial Intelligence techniques, and more specifically those of Machine Learning (ML) for detecting security threats. ML algorithms such as Decision Trees, Support Vector Machine, Naive Bayes, Artificial Neural Networks, K-means Clustering, Stacked Autoencoders have been deployed separately and combined to achieve better results[2]. To this end, the researchers started by applying each ML algorithm separately and then they combined these algorithms for better relevance results.
One of the areas where Machine Learning techniques have proven their effectiveness is that of Intrusion Detection Systems (IDS). Using the machine learning mechanism, IDS can detect new attacks, which is similar to the principles of AIS where the organism can neutralize different threats and intrusions using immune cells.

In his famous survey article, [2] presents a review summarizing more than 200 articles that have discussed instruction detection methods. These methods are either based on anomalies or network traffic specifications. The principle of IDS based on Machine Learning techniques consists of using datasets containing attributes that describe network attacks such as IP address, port number, protocol, etc. The dataset is then refined and ML algorithms are used with the aim of obtaining more relevant results by improving metrics such as recall, precision and accuracy.

The major challenge in the implementation of IDS based on Machine Learning techniques consists in the choice of the ideal location to integrate the IDS in an IoT architecture [19]. Three alternatives are then possible: an implementation at the Edge level, or at the Fog level or even at the Cloud level. This challenge remains an attractive area of research that arouses the interest of the scientific community in the field.

V. Conclusion and perspectives

The interest of the commercial and industrial world in IoT technology, and the potential that this technology offers to different technological fields, has pushed researchers to explore and propose security solutions whenever a new challenge arises. Nevertheless, the characteristics of IoT systems, in particular those related to the complexity, the limit of resources and the portability of this type of system, make the mission of proposing effective security solutions a complex, difficult and tedious task. To this end, the use of new bio-inspired approaches such as AIS seems a promising way to deal with these problems, using the advantageous characteristics of these systems, particularly in terms of distribution and self-adaptation. In this same perspective, the use of AI and ML techniques promotes the ability to find intelligent and adaptive solutions. Another important problem in the field of IoT security is that of the lack of reference models for IoT architectures, this problem generates major challenges related to communication, data management, scalability, interoperability and the lack of standardization. This axis is also a major challenge for researchers in the field.

Moreover, the appearance of the Edge, Fog and Cloud paradigms opens the way to new research perspectives, in particular those related to User-Edge, Edge-Fog and Fog-Cloud authentication. Similarly, the need to develop lightweight cryptography protocols is another challenge to overcome the problems related to the resource limits of an IoT system. Finally, the development of dedicated applications offering IoT solutions that support the different security aspects is also a major challenge, and the emergence of new paradigms such as cloud based programming models are attractive lines of research that are now very present in recent research work related to security in IoT systems IoT

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Contribution of Quantum computing to Natural Language Processing

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1st Yousra BOUAKBA
LISIA Laboratory , NTIC Faculty, University of Constantine 2 - Abdelhamid Mehri

Constantine , Algeria
yousra.bouakba@univ-constantine2.dz

***Abstract*—The intersection of Natural Language Processing (NLP) with Quantum Computing seems to be quite popular over recent years, enabling to create a new sub-field which is the Quantum Natural Language Processing (QNLP). This new sub- field designing algorithms that process natural language in quan- tum computers. So far, approaches have ranged from those that illustrate the quantum advantage purely theoretically to those that realize algorithms on quantum hardware. The purpose of this article is to clarify the major features and advances of QNLP. Then briefly describe our proposal research including search problem, objectives, idea to explore, and expected outcomes.**

***Index Terms*—**

I. Introduction

Machine translation, question answering, text classification, sentiment analysis ,text generation, and many other NLP applications have been considerably enhanced by recent developments in neural language models based on deep learning architecture. Transformers-based models such as BERT [1] in particular, has demonstrated superior performance than current-generation state-of-the art architectures like Long Short Term Memory (LSTM) and Recurrent Neural Networks (RNN).
As an example, the BERT Large uses 24 layers of transformers block with a hidden size of 1024 and number of self-attention heads as 16 and has around 340M trainable parameter [8]. Because more parameters and data are needed to train this type of models efficiently, there is a cost in terms of time, resources, and computing power. This results an increase in model complexity. Therefore, it is necessary to search for new ways to process natural language with less complexity.
However, quantum computing has attracted a lot of attention recently. The fundamental idea is to use quantum mechanics to solve computational problems, in order to following different paths of computation at the same time, quantum computers can make use of a qubit's superposition of two quantum states $|0\rangle and |1\rangle$.
A significant advance in quantum computing was made by quantum algorithms such as Short [9] perform calculations with lower complexity than conventional methods .Naturally, the field of machine learning benefits from the ideas that quantum computing has to offer which led to the emergence of a new sub-field called Quantum Machine Learning (QML). In this last, there is two main approaches:the first,try to find quantum algorithms that can replace conventional machine learning methods to resolve a problem and demonstrate how a complexity improvement can be obtained. This is particularly the case for closest neighbor kernel, and clustering algorithms, in which expensive distance computations are sped up by quantum processing.The second one uses the probabilistic description of quantum theory to describe stochastic processes, which helped to generalize the hidden quantum Markov model while Bayesian's theory was also applied to real quantum information tasks like quantum state discrimination. [14]. Processing classical data with machine learning algorithms on quantum systems have recently gained prominence such as supervised [10], and unsupervised learning [2] [3]. Quantum image processing (QIP) is one of QML application that aims to expand traditional image processing tasks and operations to the quantum computing environment.It is largely concerned with using quantum computing technologies to capture, manipulate, and recover quantum images in various formats [15], [16], [17] and for diverse reasons .
The following is how this paper is structured: The significant advancements in the field of QNLP are summarized in section II. Section III then explains our search problem and the essential objectives. Lastly, section IV describes the idea to explore, the methodology, and the expected performance.

II. State of the art

The need to expand the NLP field in new directions coincided with the development of quantum computing, in particular quantum machine learning, which resulted in the emergence of so-called Quantum Natural Language Processing (QNLP), which represents today one of the best applications of quantum computing. The concept behind this implementation of natural language on quantum hardware is to create a *link between language meaning and grammatical structure and quantum states*.This connection is made using the Categorical

Distributional Compositional (DisCoCat) model [4],where the meanings of words are vectors in vector spaces and words grammatical roles are types in a Pregroups then a tensor product of vector spaces paired with the Pregroup composition is used for the composition of (meaning, type) pairs.

Authors in [5] demonstrate that a quantum algorithm for calculating phrase similarity yields a quadratic speedup over conventional approaches under specific conditions. However, it requires quantum random access memory (QRAM), which is costly and has yet to be implemented.

As a result, [6] and [7] articles presents quantum algorithms that can potentially be implemented in current NISQ devices (Noisy intermediate-scale quantum). These last papers assume that NLP is quantum native, in the sense that the exponentially massive vector space necessary to represent sentences can only be realized naturally and practically in quantum computers. Following that, various investigations in the literature have shown that quantum speedup is more likely to impact NLP tasks like question answering [8] [9], machine translation [10] and classification [11].

In order to close the gap between theory and practice, eventually contributing to actual real-world QNLP implementations, Cambridge Quantum Computing present Lambeq ,' an open-source, modular, extensible high-level Python library, which provides the necessary tools for implementing a pipeline for experimental QNLP. At a high level, the library allows the conversion of any sentence to a quantum circuit, based on a given compositional model and certain parameterisation and choices of ansatze' [13]. This first high-level open-source Python toolkit for quantum natural language processing is still in progress to offer a fully automated quantum machine learning pipeline .Recently, Lambeq has been used in sentiment analysis task [14].

The key challenge in Quantum Natural Language Processing is that Transformers-based models have already achieved high accuracy in several NLP tasks. Nevertheless, Due to the present restrictions imposed by NISQ computers and Lambeq toolkit, the datasets on which these algorithms have been tested are still quite limited (approximately 100 natural language words in medium-scale experiments).

III. Research Problem and Objectives

As mentioned in the previous section, quantum NLP algorithms could well be utilized for information retrieval, question answering, and other elementary tasks.However quantum NLP models have not been adapted to more difficult tasks like text generation or automatic summarization. Finding more NLP tasks that can benefit from quantum physics is yet another unexplored field.

So our objectives include:

- use a large data-sets,
- develop quantum NLP model for more difficult tasks,
- propose quantum Generative Adversarial Networksb (GAN) for NLP tasks,
- run our quantum NLP model on a real quantum computer for more realistic results

IV. Idea to Explore and Methodology

Our first objective is based on exploring the use of quantum computing for classical tasks such as classification and clustering by using quantum machine learning algorithms based DisCoCat model on NISQ device, that can reduce computation time and improve the process accuracy, as well as in the second one, we plan to generalize the proposed solutions on difficult tasks such as text generation and text summarization.

V. Acknowledgment

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Data augmentation techniques for Deep learning medical decision analysis

1st Khadija Rais
LAMIS Laboratory
University Larbi Tebessi
Tebessa, Algeria
khadija.rais@univ-tebessa.dz

2nd Mohamed Amroune
LAMIS Laboratory
University Larbi Tebessi
Tebessa, Algeria
mohamed.amroune@univ-tebessa.dz

3rd Mohamed Yassine Haouam
LAMIS Laboratory
University Larbi Tebessi
Tebessa, Algeria
mohamed-yassine.haouam@univ-tebessa.dz

***Abstract*—One of the challenges of deep learning is the small amount of data and with the development of data processing and neural network algorithms, data augmentation is becoming an important approach in deep learning. Sometimes we need a lot of data and we can't collect it, so we use data augmentation to avoid data limitation issues, especially the most sensitive ones in medical fields for example. Also, when we generate data, they will be of the same type, we will have no difference, and we avoid the loss of information value in the preprocessing process.**

Whether it is a text, an image, an audio, or a video, data augmentation is a regularization technique that aims to generate data from a dataset in order to minimize "overfitting" and increase dataset size to improve performance.

Selecting a technic that corresponds to your data demands is crucial to ensuring that data augmentation plays a significant role in quality and results.

***Index Terms*—Deep learning, Data augmentation, Regularization technique, Overfitting, performance, Datasets.**

I. Introduction

In numerous branches of computer vision and pattern recognition, deep learning has become the state-of-the-art [5], it faces many challenges, including lack of data, poor quality or limits of diversity. The effectiveness, accuracy, and complexity of machine learning and deep learning tasks are significantly influenced by the quality of the training data. While being collected, compiled, or annotated, data is still subject to mistakes or anomalies. To understand the suitability of data for machine learning tasks, it is necessary to profile and evaluate the data; failure to do so may result in inaccurate analysis and unreliable decisions. [4], therefore, quantity and quality must be taken into account, to avoid problems that can occur during training.

We require a vast amount of ground truth data in order to develop well-generalizing deep models, in order to prevent overfitting of such large-capacity learners and "memorizing" training sets. [5], when there is a very small training error and a very high validation error, overfitting is evident. And it is usually due to one of the following causes [2]:

- The optimal size of the network.
- Considering that the input collection contains outliers (this causes the variance of the network to be high).
- When using resolution methods that are very complicated.
- When an excessive amount of data is used during training.

We must know that data augmentation is very important in machine learning to face the problems of lacking or not having enough training data. The term "data augmentation" (DA) refers to techniques that increase the diversity of training data without directly accumulating additional data. The majority of techniques add some modified copies of already existing data (flipping, cropping, rotation, translation, etc) or produce fake data such as Generative Adversarial Networks . [3].

DA is used for several reasons, the most important of which are:

- When training ML models, augmented data can act as a regularizer and minimize the overfitting. [3].
- Useful for improving the generalization capabilities of a model [1].
- Overcoming the lack of training data [1].
- Reduce the amount of data used to maintain privacy [1].

Increasing data is very effective in increasing performance. Due to the limitations of dataset with precise annotation, the samples usually are insufficient when training a deep learning model, which is one of the main factors reducing the performance of the model, To overcome this issue for example, data augmentation methods generate additional samples for model training in [6] experimental results show that data augmentation plays an important role in improving the accuracy of detection models , in which the impacts of the data augmentation methods are significant .

The objectives of data augmentation are numerous and cover various areas mentioned in [1], while the choice of classifier has little impact, adding more data may improve the quality of a solution to the confusion set disambiguation problem. Utilize the enormous amount of data at minimal cost, as producing training data for various categorization issues needs expensive labeling, resources, time, and staff. We conclude that its benefits include improving model performance, adding more data, reducing data overfitting, decreasing the cost of data collection and labeling, avoiding problems with confidentiality, etc. Among the challenges of data augmentation mentioned in [1]:

- Generative models or their output should depend on the specific class. Otherwise, instances created may not retain the label.

- The generative models themselves provide another challenge because they can take a lot of time and resources to produce new instances.

Also we have:

- Generating data from some techniques can be complicated and difficult.
- Data augmentation will not work if the imbalance of data is in the dataset.
- Determining the augmentation technique is in itself a challenge.

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Healthcare systems and ambient intelligence

Hana Djeddi
dept. Mathematics & Computer Science
(of Larbi Ben M'hidi University)
Oum El Bouaghi, Algeria
hana.djeddi@univ-oeb.dz

Dr. Asma Saighi
dept. Mathematics & Computer Science
(of Larbi Ben M'hidi University)
Oum El Bouaghi, Algeria
pgasma_saighi@yahoo.fr

Pr.Makhlouf Derdour
dept. Mathematics and Computer Science
(of L'arbi Ben M'hidi University)
Oum el Bouaghi, Algeria
derdour.makhlouf@univ-oeb.dz

***Abstract*—Ambient intelligence (AmI) is an emerging discipline that stands intrinsically and thoroughly connected with artificial intelligence (AI). AmI is considered one of the recent technologies that support hospitals, patients, and personal healthcare, where it can improve and sustain the quality of life without increasing financial or care burdens, that's why our main aim is to develop a distributed system based on Aml and AI to improve the healthcare systems. This paper examines the background behind this particular strand of AmI research along with dis- cussing some of the recent research in this field.**

Keywords— Healthcare, Ambient intelligence, Artificial in- telligence, IOT.

I. Introduction

Usually, traditional healthcare services are provided only in hospitals and medical centers [1]. However, many patients suffering from particular diseases require long healthcare and due to overcrowding in hospitals, especially during periods of pandemics such as infectious diseases(ex: Covid-19), it has become necessary to search for modern and smart systems for effective healthcare inside and outside hospitals.

Otherwise, ambient intelligence is an emerging form of tech- nology that can help healthcare workers like doctors and nurses deliver quality care in different spaces (hospitals or daily life). Precise sensors transmit the information from the environment are needed to be used as inputs by machine/deep learning models.

Actually there are two type of studies, one about healthcare in hospitals and other for daily life.

Many researchers have been interested in this field, especially at the period of the Covid-19 pandemic, where they presented studies and systems that contributed to reducing infection and monitoring the condition of infected persons during the home quarantine.

In order to implement an intelligent distributed solution based on ambient intelligence to achieve the goal of protecting and monitoring the human health beings, we focus on approaches that describe the use of ambient intelligence such as human-machine interactions HCI (Human Computer Interactions) and proxemics physical dimensions : Distance, Identity, Location, Movement and Orientation (DILMO) and distributed systems in the field of healthcare.

The aim here is to present our first step by giving an overview of the related works in this field.

I. The different axes in research

In 2018, approximately 7.4 per cent [2] of the population inthe United States required an overnight hospital stay. In the same year, 17 million admission episodes [2] were reported bythe National Health Service (NHS) in the

United Kingdom. Yet, healthcare workers are often overworked, and hospitals are understaffed and resource- limited.

According to these numbers, they provided some hospital spaces in which ambient intelligence can play an important role in improving the quality of healthcare delivery and productivity of the clinicians, such as: waiting halls, operatingrooms and intensive care. These improvements could be of great assistance during healthcare crises, such as pandemics, which make hospitals encounter a surge of patients [2].

As mentioned in [3], micro-sensor devices and smart systems can also monitor the health of the patients outside clinics and hospitals, especially older people who live alone and in remoteplaces, by analyzing the data of these devices for early diseaseprediction, rapid intervention, and risk avoidance.

In literature, several recent research works have been carried out, among others [4, 5, 6, 7, 8, 9].

II. Related work

Rodriguez et al. proposed an Agent-based ambient intelligence for healthcare called SALSA. This agent is an intermediate software designed to support the development of standalone agent-based AmI environments [4].

Another Smart Health Monitoring System proposed by Arora and dr Goel, measure the heart rate, tem- perature and respiration, whenever one of the indicators is not normal, an alert is sent to the patient and to a nurse to conduct the necessary tests [5].

Also Gomeza et al. proposed a Patient Monitoring System Based on Internet of Things, it is a distributed system that allows monitoring of health recommendations and routineexercises for patients with chronic diseases [6].

Other researchers present how the Internet of Things and 5G technology can help intelligent healthcare systems with the support of an enormous number of devices, standardization, energy efficiency, system density, and security [7].

Muhammad Saqib et al. proposed a system to monitor older people's health it is a device placed in the hands of patients that measures vital values and sends them to a webpage that monitors patient status and predicts disease quickly using machine learning techniques [8].

Recently several researchers focused on new ways to reduce COVID-19 infection in hospitals and public facilities by monitoring personal spacing and erroneous habits using cameras and artificial intelligence (AI) techniques [9].

In our work we will focus on the limitations of efficiency and shortcomings of the other works such as speed in intervention "Due to the sensitivity of the field, the speed of intervention to rescue patients is very important, but in fact it is a great challenge, espeially when we deal with sensors and real-time systems", and since the protection of patient data and privacy is the biggest challenge for any researcher who wants to work in this field, security is the biggest shortcoming in the previous works this is what makes it missing reliability, flexibility, validity.

III. Conclusion

In this paper an overview of the role and the importanceof ambient intelligence in protecting human health, whether,in hospitals or in daily life, were presented as well as someof the researchers' works in this field. As a future orientation, we intend to conduct additional research on smart healthcare systems about the limitations of efficiency and shortcomings of the other works.

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Intelligent Medical Decision Support System

1st Nadjem Eddine MENACEUR
dept. Mathematics and Informatics
Larbi Ben M'hidi University
Oum El Bouaghi, Algeria
nadjemeddine.menaceur@univ-oeb.dz

2nd Sofia KOUAH
dept. Mathematics and Informatics
Larbi Ben M'hidi University
Oum El Bouaghi, Algeria
kouahs@yahoo.fr

3rd Makhlouf DERDOUR
dept. Mathematics and Informatics
Larbi Ben M'hidi University
Oum El Bouaghi, Algeria
derdour.makhlouf@univ-oeb.dz

***Abstract*—The healthcare sector embodies protection for humans' life. The priority that it is witnessing motivates countries to spend a lot of their budget for the development of healthcare infrastructures, as well as scientific research field to find solutions to problems that are considered global, such as Covid 19 pandemic. Accordingly, using Smart Health technologies that rely on a set of distributed sensors and assistive decision-making systems is highly recommended. Applied on Medical field, Internet of Things is considered as key stone and it is named Internet of Medical Things. Patient data are important, they are gathered from medical devices and sensors and transmitted to practitioners in order to be processed, diagnosed and saved together with achieved decisions. This paper deals with intelligent medical decision support system. It aims at providing an overview of our research, where we intend to propose an intelligent system for diagnosing cardiovascular diseases by means of Internet of things as well as artificial intelligence methods.**

***Index Terms*—Internet of Things, Artificial Intelligence, MIoT, E-health, Machine learning.**

I. Introduction

The set of all things that are embedded with sensors and processing systems and can create a small to a large network that we call it the Internet of Things (IoT). It's the combination of physical and digital objects that allows us to collect data from many physical resources that support decision-making or industry driven-data for example robots that install parts of cars to manufacture [1]. Internet of things is used in many fields such as Business, Military, industry, and also astronomy, and geology nonetheless the great step that was taken is in healthcare field where IoT nodes become smarter by using Artificial intelligence and sensors that return accurate values. It has facilitated the design of Smart Healthcare System to diagnosis and prognosis extremely large disease states [2].

A. context

This work focuses on Smart Healthcare Systems which relies on sensors that collect information and transform it to be treated using algorithms that help in making diagnosis medical decisions, early diagnosis, and disease prevention. The development of smartwatches, smart bands, and other embedded technologies that monitor biometrics is shifting from healthcare to personal care as the Internet of Things creates new ways of working in medicine, such as interacting with patients via portable devices or in the car. It is now possible to connect smart healthcare devices, machines, and systems to a distributed network to form a new integrated paradigm: the medical Internet of Things [3].

B. Problematic and Justification

This work deals with medical decision support, considered a sequence of three stages: Diagnosis, Prognosis, and Therapeutic Decision. We are mainly interested in the first step Diagnosis, in which other steps are intrinsically correlated. It consists of giving a precise identification of a particular disease by analyzing various information, such as signs, symptoms, clinical examination, laboratory tests, imaging tests, functional tests, etc [4].

As a pathology, we opt for cardiovascular diseases. According to the World Health Organization, cardiovascular disease is the leading cause of death worldwide. Cardiovascular diseases (CVDs) are the first-place cause of death in the world, each year it's taking an estimated 17.9 million lives [5]. They include several pathologies that affect the heart and all the blood vessels, such as heart rhythm disorders, arterial hypertension, pulmonary embolism, or strokes. Patients with cardiovascular disease or at high risk of cardiovascular disease require early detection and management including psychological support and medication, as needed. Hence the need for a rigorous process of diagnosing such diseases.

C. Objective

It should be noted that proposing a generic approach for diagnosing various diseases at time is seductive idea. However, each disease has its specificities and the underlying diagnosis process. Also, the inherited complexity is high and the expected results are not garneted. Moreover, dealing with several diseases at time require a great number of sensors and medical devices motivated by the use of IoMT technology. Thus, a comprise could be found on the basis of several parameters that should be defined later.

We begin with studying several frequent cardiovascular diseases in order to choose a pathology to be diagnosed. In fact, the management of such kind of diseases represents a challenge at several levels, given its seriousness, its difficulty of diagnosis, the complexity of the care process as well as the incomplete and imprecise nature of the handled information. In this regard, the aim of this work is to propose an intelligent medical support system for diagnosing a particular cardiovascular disease which cope with imprecise and incomplete information. To do so, several alternatives could be pursued. We opt for using Artificial Intelligence paradigms, IoMT technology as well as newest information and communication technologies such as Cloud Computing, Fog Computing, Communication Protocols without forgetting considering security aspects and patients confidentiality.

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Learning from Historical Data in a Big Data Environment: Application to Syndromic Surveillance

Lamia Bendebane
dept. Mathematics & Computer Science
(of Larbi Ben M'hidi University)
Oum El Bouaghi, Algeria
lamia.bendebane@univ-oeb.dz

Dr. Zakaria Laboudi
dept. Mathematics & Computer Science
(of Larbi Ben M'hidi University)
Oum El Bouaghi, Algeria
laboudi.zakaria@univ-oeb.dz

Dr. Asma Saighi
dept. Mathematics & Computer Science
(of Larbi Ben M'hidi University)
Oum El Bouaghi, Algeria
pgasma_saighi@yahoo.fr

***Abstract*— The aim of this paper is to give an outline of the research-works carried out as part of my doctoral thesis. The overall objective is to develop new effective syndromic surveillance systems in order to contribute to the improvement of healthcare systems. To this end, we first sketch the general methodology that we adopt namely sentiment analysis of social media data. Next, we highlight our ongoing research-works that focus on analyzing Twitter social data for predicting mental disorders.**

Keywords—historical data, big data, data analysis, healthcare, syndromic surveillance, mental disorders.

I. Introduction

The use of historical data is supported by many systems as it helps provide knowledge about individuals so that these data can be taken into account in future processing in the form of various advantageous tasks. We cite as examples applying machine learning approaches, building recommender systems, personalization, etc. Historical data are extremely diverse and processing them is unfortunately quite complex. This is due to the lack of standards describing the granularity, structure, content, format, and level of detail provided by events [1]. This raises certain questions related to their extraction, storage, and exploitation, in particular, that large volumes of data may be processed often as big data.

Syndromic surveillance refers to real-time (or near real-time) collection, analysis, interpretation, and dissemination of health-related data to enable the early identification of the impact of potential human or veterinary public health threats that require effective public health action. The systems collect health data in real or near real-time to track trends in the occurrence of disease conditions of public health importance in a defined population [2, 3].

In fact, the expansion in digital technology and increasing access to online user-generated content has provided a relevant source of data for syndromic surveillance purposes [2]. In this respect, social media data can significantly help develop such systems. Indeed, social media has become an essential need for human existence as every day, millions of people share their thoughts, feelings, and experiences through Facebook, Instagram, Twitter, and so on. This large use of social media has resulted in the generation of very large volumes of data, which has encouraged conducting many researches to analyze them data through systematic, structured, and efficient methods.

The main aim of our study is to develop new methods that exploit social media data in order to build efficient syndromic surveillance systems. To achieve this goal, we have to deal with the following challenges:

- The first concern is about the determination of the data that will be processed; this is a crucial issue that depends on the purposes for which the data will be processed.
- The second concern is about the format in which the data will be stored and processed. This directly affects the efficient storage and retrieval of data for further processing, in particular since this can lead to large volumes of data.
- The last concern is about the way in which the stored data will be used in useful tasks leading to contributing to the improvement of health systems to protect and monitor the health of individuals through efficient syndromic surveillance systems.

II. Research methodology

In order to propose relevant contributions related to the above-stated objective, we will rely on sentiment analysis which has emerged as one of the most important techniques to analyze the contents of social media, for healthcare purposes. Indeed, prior to the laboratory confirmation of infectious disease, ill persons may exhibit behavioral patterns, symptoms, signs, or laboratory findings that can be tracked through social data. Thus, social media posts provide a rich source of data since people are ready to share their sentiments and problems on social media, hoping that they find solutions to their problems due to the vast spread of social networks. That is why it is believed that social media giants can significantly help us in such cases.

III. Work in progress

Currently, we are working on applying sentiment analysis techniques for predicting mental disorders through Twitter social data. Twitter sentiment analysis relies specifically on Twitter social data represented by tweets (a message posted to Twitter containing text, photos, a GIF, and/or video). Several unstructured free-text tweets related to healthcare are shared on Twitter, which is becoming a popular area for doing research. Most of these researches are based on people discussing about their healthcare cases on Twitter, sharing their illness, indications, and drugs; all these experiences are covered in sentiment analysis, which is in fact the power source of that kind of analysis. From this standpoint, many researchers have focused their efforts on the analysis of tweets in order to detect mental disorders such as anxiety, bipolar, schizophrenia, autism spectrum, and depression [4-16].

In view of the foregoing, a social media syndromic diagnostic system is recommended in order to identify if the user is normal or he is suffering from psychiatric illness, such as bipolar or depression based on their past publications, tweets, and like/dislike reactions. Then after, the system has to apply certain measurements according to the examined state of the user. For instance, if the user is examined with depression, he will receive probably more publications about religious and life citations, some experiences of persons who had the same illness and have battled it, or the profiles of psychiatrists that could always answer their questions. Furthermore, the system must consist of a surveillance module that should follow the ill users periodically by examining their new history (publication, tweets…) and identifying if their states get better or worst. In the former case, the system will apply the same recommended measurements. Otherwise, the system contacts and informs a near volunteer psychiatrist (based on their coordinates) of the difficult state of the user. The psychiatrist establishes a weekly online session with the user. In the end, the syndromic diagnostic system could build an acknowledgment database about the behavior of ill users on social media, which may help doctors and scientists to understand them and discover their hidden symptoms (e.g., users examined with depression 90 percent of them use the word "getting tired of" in their publications and 40 percent recover quickly). The system uses the techniques of supervised learning or deep learning for classifying the state of the user based on some sentences in their tweets, publication, and the number of likes or dislikes (if he likes a happy publication or sad publication...) into three categories normal, bipolar or depression (you could consider more based on the number of datasets that you find). The surveillance module is also implemented using deep learning techniques. It examines the previous state and the new publications of the user to measure his recovery state (It could be a classification better or worst) [17-21].

IV. Conclusion

The aim of this short-paper was to provide details about our research-works as well as the expected outcomes. The global objective we target is to contribute to improving healthcare systems through new effective syndromic surveillance systems. To do so, we have first presented the outline of the adopted methodology that relies on sentiment analysis of social media data. Then, we have highlighted our works in progress, in which we focus on analyzing Twitter social data for predicting mental disorders.

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Brain Tumor Segmentation on BraTS 2020 Using U-Net

Yahiaoui mohammed elbachir
dept. Computer Sciences
Larbi Tebessi University
Tebessa, Algeria
yahiaoui.mohammedelbachir@univ-tebessa.dz

Mohamed Gasmi
LAMIS Laboratery
Larbi Tebessi University
Tebessa, Algeria
mohamed.gasmi@univ-tebessa.dz

Makhlouf Derdour
dept. Computer Sciences
Larbi ben M hidi University
Oum el Bouaghi, Algeria
derdour.makhlouf@univ-oeb.dz

***Abstract*— Tumor segmentation is a fundamental task in radiosurgery planning and the assessment of radiotherapy treatment efficacy. However, it is a challenging problem to achieve higher accuracy and performance, which is a vital problem in most of the previously presented automated medical segmentation. Although Unet network have widely applied to this task, it has reached a satisfactory level of performance in term of medical image segmentation due to their learning ability and its powerful symmetric architecture. In this paper, we propose two neural networks architectures based on the Unet network to segment different tumor sub-regions using the Flair modality in Brain Tumor Segmentation Challenge (BraTS) 2020 training dataset. The first architecture is a 3D U-net and the second is similar to the first, it was obtained by transferring all the operations and 3D layers of the 3D U-net network to their 2D versions. We experiment both architectures with four outputs, then we reduce the output number to three (without background). Our best model is capable of segmenting gliomas on the training dataset with a Dice similarity coefficient of 0.80, 0.75 and 0.80 for the whole tumor, tumor core and edema tumor respectively. When compared to other architectures on BraTs2020 dataset, 3D U-Net architecture provides better results.**

Keywords*— *3D convolutional neural networks, BraTs2020, brain tumors

I. Introduction

A brain tumor is a growth of cells in the brain that multiplies in an abnormal, uncontrollable way. It can be found to be a primary or secondary. Primary originate in the cranial cavities whereas secondary originate in other parts of the body and can metastasize throughout the body [1]. Due to the high mortality rate and incidence, malignant gliomas are the most common primary brain tumors. According to the World Health Organization (WHO) classification criteria, they can be categorized according to their different degrees of aggressiveness with various histological subregions and varying degrees of invasiveness, into two levels: High Grade Gliomas (HGGs) and Low-Grade Gliomas (LGGs) [2]. LGG tumors are slow growing and less aggressive, while HGG are tumors with high rate of mitotic division, accelerated growth and rapidly invading surrounding tissues [2]. The brain lesions are detected, treated and monitored by many methods including CT scans and EEG, however, the quintessential technique most successful and commonly used is the MRI. MRI utilizes strong magnetic fields and radiofrequency waves to improve vision and make it more clear in order to distinguish among the different characteristics of the tumor through weighted sequences such as T1, T1 with contrast (T1Gd), T2 and T2 with Fluid Attenuation Inversion Recover (T2-FLAIR) [3].

At present, radiologists and other clinicians find it difficult to make a clinical review of MRI scans which requires a great deal of time and effort since it is not yet common to have a protocol to process and analyze this information automatically or semi-automatically [4]. The use of deep learning techniques has produced extremely promising results in medical tasks such as detection and segmentation comparable to those carried out by specialists [5] highlighting, Deep convolutional neural networks (DCNNs) which can learn features automatically and deal with complex images and achieve remarkable performance, especially in brain tumor segmentation [6]. Unfortunately, for the training and testing of these algorithms researchers often face difficulties in obtaining medical datasets which are limited or are mostly private data; therefore, until now, there has been a few amounts of biomedical data available publicly. The Brain Tumor Segmentation Challenge (BraTS) is focused on evaluating state-of-the-art methods for segmentation of brain tumors in MRI. The BraTS 2020 dataset delivers presurgical MRI images of 76 Low-Grade Glioma (LGG) patients and 293 High-Grade Glioma (HGG) patients with pathologically confirmed diagnosis [7] for model training, validation and testing.

In this work, we describe our glioma segmentation method based on the two- and three-dimensional versions of the U-net architecture. We designed the same network architectures to compare the effect of neural network dimension on their performance during the inference time for segmentation tasks. Besides, in both architectures we use batch normalization, we also make several optimizations by varying the different values of hyperparameters such as the size of the kernels, number of epochs, learning rate, optimizer and dropout in order to understand the impact of each of them on the final result of our networks. Related work is provided in the next section, our proposed methodology, experimental setting, results and discussions and conclusion and future scope in section III, IV, V and VI respectively.

II. Related Work

Over the past several years, deep learning algorithms for the classification, detection and segmentation has evolved into a new trend in medical neoplasms. Ronneberger et al. proposed a new neural network architecture called U-net for the segmentation of biomedical images, this architecture consists of a contracting and a symmetric expanding path with the presence of layers of convolution, max pooling, upsampling and skip connections.This model won the ISBI cell tracking challenge 2015 [8] And it is also the basis of numerous other studies such as the one conducted by Rondo et al. in which they apply two different networks by replacing all U-net 2D operations with their 3D versions and replacing all its skip connections with concatenation blocks for the first network. The second architecture is similar to the first by adding a max pooling layer, a transposed convolution layer and a concatenation block. In both architectures the group normalization layer was used as a suggestion of the state-of-the-art [9].

Maram proposed a suitable U-Net model. The framework mainly focuses on the detection of brain tumor MRI images from the BraTS2020 dataset and the main objective is to avoid overfitting, incremental classification accuracy, and speed of training time [10]. Havaei et al. [11, 12] in their study, introduce a deep learning image segmentation framework that aggregates partial modalities by calculating the mean and variance of the available features. Dorent et al. [11, 13] propose a new deep learning method for tumor segmentation based on hetero-modal variational 3D encoder-decoder, this model independently embeds all observed modalities into a shared latent representation. Chen et al. [11, 14], in order to obtain a modality-invariant and discriminative representation they propose a network that aggregates incomplete modalities via concatenation and leverage feature disentanglement jointly.

In other work, Myronenko won first place in the BraTS 2018 challenge. He describes a semantic segmentation approach for volumetric segmentation of gliomas. He followed an encoder-decoder neural network structure with an extensive asymmetric encoder to extract deep image features, he also added a Variational Autoencoder (VAE) which is used only during training process to regularize the encoder [15]. Deependra et al. proposed a successful 2D-VNet model which achieve the highest dice coefficient in terms of segmentation of brain lesions areas [16]. Aziz et al. optimized a model based on the capsule neural network called SegCaps, to identify the exact boundaries of the tumor in an MR image. The SegCaps uses convolutional layers as the basic components and has the intrinsic capability to generalize novel viewpoints. The network learns the spatial relationship between features using dynamic routing of capsules. These capabilities of the capsule neural network improve the segmentation results by up to 3% with fewer data while it contains 95.4% fewer parameters than U-Net. The only evaluation criterion applied is the Dice Similarity Coefficient (DSC) [17].

III. PROPOSED METHODOLOGY

In this work, we design a simple two-dimensional U-net and its 3D version to approve the segmentation of tumor substructures. We take advantage of the good performance of this framework to learn complex patterns in biomedical pictures. We use brain Tumor Segmentation (BraTS2020) as a benchmark for the automatic brain tumor segmentation which contains MRI scans of 369 patients with ground truth in four modalities (T1, T2, T1-Gd and FLAIR) in NIfTI file format which is a commonly used format to save images of brain data. In this case, we choose only FLAIR MRI to extract necrosis and non-enhancing tumor core (NCR-NET), enhancing tumor (ET) and peritumoral edema (ED) classes. A sample of the training dataset as shown in Fig. 1. In addition, we also propose a segmentation-based on three-outputs (NCR-NET, ET, ED) and another one included background label to further visualize the impact of this parameter on the final segmentation results. Each step performed is detailed in the following subsections.

Identify applicable funding agency here. If none, delete this text box.

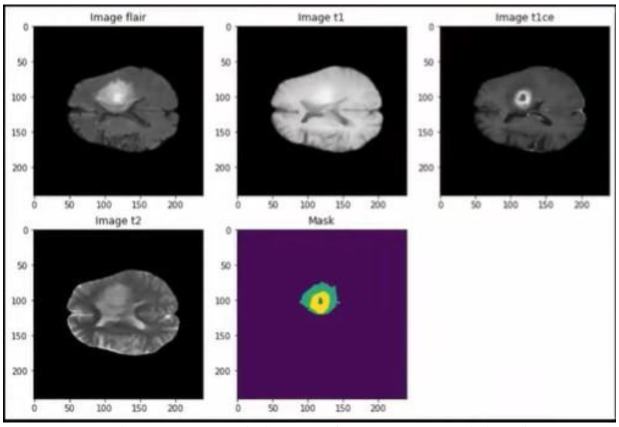

Fig. 1. Sample image of BraTS2020 training dataset

A. Preprocessing

The input is a series of FLAIR images scaled between 0 and 1, then cropped to have patches of 128x128x128 voxels for the 3d model and 128x128 voxels (only the last axe was used) for the two-dimensional one. We accept only images that contain at least 1% useful volume with labels that are not background. For masks, we changed each pixel values to be categorical before feeding it to the network architectures.

B. U-net Architectures

The adopted architecture is a modified three-dimensional version of the U-net and is composed of three essential parts. The left section is the contraction path, is composed of the achievement of convolution blocks, max pooling, dropout and ReLU activation layers to prevent the linearity of the model. The right section is the Expansive path, which contain several convolution blocks, transposed convolution layers, dropout operation and concatenation blocks. and the last section is the bottleneck.

The left and right sections are connected by skip connections. During the contraction stage, each contraction block contains Two 3X3X3 convolution layers with a dropout operation in between to prevent overfitting, each followed by a max pooling of 2X2X2 operation to reduce the size of the patch by a factor of 2. After each block, the model can efficiently learn to distinguish between the different tumor parts due to the increasing number of kernels. Among each contraction block, the pre-defined value of filters doubled after each downsampling which affected the number of output networks. Note that, the bottom layer is made up of two layers of 3X3X3 CNN, followed by 2X2X2 up to raise the resolution to its native input resolution.

Furthermore, the decoder component is mostly symmetrical with the encoder. Upsampling layers double the number of features by a factor of two and reduces Filters number by the same factor. Four concatenation blocks relate the characteristics maps of each block in the contraction path with its corresponding in the expansion stage, Fig. 2 shows the arrangement of each block in relation to others.

Finally, a 3-channel 1x1x1 kernel with a stride of 1and sigmoid activation was used by the last convolutional layer. Number of filters equal to 3 (if we ignore the background) infers the classes that make up each tumor substructure. Our second model is a 2d version of the network described in the previous subsection.

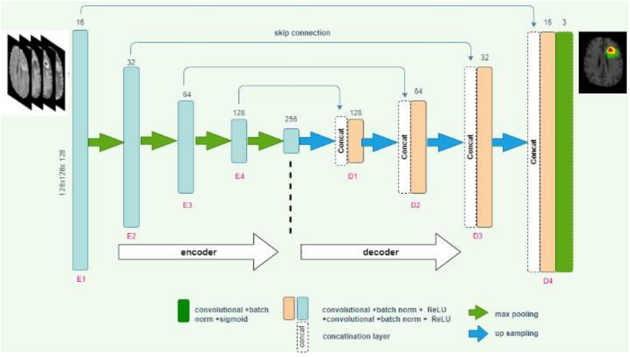

Fig. 2. 3D U-net architecture dataset

IV. EXPERIMENTAL SETTING

Our models were trained in the BraTS 2020 training dataset. For the 3D model, we split our input data into 258 cases for training process and the remaining 86 were used during the validation time. However, for the 2D version, we divided the dataset into 18992 cases for training and 6364 for validation.

In this work, through a proof and error process we obtained the optimal hyperparameters values for our application. We used a batch size of 2 and learning rate of 0.0001 which did vary during the training process according to the change on the validation loss in certain number of epochs. The focal loss was used and achieved a good convergence of the model losses. The model was trained for 200 epochs and a combination of dropout value between 0.1 and 0.2 was used. We employed the Adam optimizer.

V. RESULTS AND DISCUSSION

In Table 1, we compare our methods segmentation results in terms of Dice score with the results obtained in [10], HeMIS [11, 12], U-HVED [11, 13] and RobustSeg [11, 14] for both training and validation data. Note that, all models conduct experiments on only BraTS 2020 dataset. Therefore, our validation set extracted and choosed from only Flaire modalities and the segmentation masks predicted by different methods dimensions.

The proposed 2D-Unet 4-Output obtained an average training Dice score of 60.00%, 68.20% and 70.00%, as well as Average validation Dice score of 47.00%, 59.00% and 46.00%, for the edema, the whole tumor and the tumor core. The Average of training accuracy and Average validation accuracy is 99.10% and 98.20% respectively. Our 3D model 4-Output did not perform better than the previous one, it shows the worst results ever in all metrics. We hypothesize that the main reason is because the unbalanced data that directly affects the convergence of the model, we also tried adding more convolution blocks in deeper networks, in no case significant improvements were obtained.

TABLE I. MODELS PERFORMANCE RESULTS ON THE BRATS 2020 TRAINING DATASET STYLES

SOURCE	Method	TYPE OF IMAGE	Dice			Dice Score
			WT	TC	ED	
[10]	U-Net 2-output	Multimodal	-	-	-	0.28
[11, 12]	HeMIS	Flair	0.52	0.24	ET: 0.09	-
[11, 13]	U-HVED	Flair	0.82	0.51	ET: 0.20	-
[11, 14]	RobustSeg	Flair	0.82	0.60	ET: 0.34	-
Proposed Method1	3D U-Net 3-output	Flair	**0.80**	**0.75**	**0.80**	**0.86**
	3D U-Net 4-output	Flair	-	-	-	0.11
Proposed Method2	2D U-Net 3-output	Flair	0.75	0.72	0.65	0.62
	2D U-Net 4-output	Flair	0.68	0.70	0.60	0.56

U-Net architecture with 3-output achieve better Dice score when compared to U-Net 4-output framework. The 2D models produced an average improvement between 2 and 7% in term of Dice metric for each tumor region. In terms of performance metrics, this model obtained 0.93 training accuracy while validation achieved 0.94. The 3D approach presents an average improvement of 24.00% on the dice coefficient and an average decreasement of 20.10% on accuracy compared to the 2D model. For each tumor region the models produced a Dice metric greater than 0.75.

Moreover, training accuracy and validation accuracy in [10] reached 98.485% and 98.411% respectively and also the average training dice coefficient and Average validation dice coefficient is 27.672 and 28.577% respectively. For the three state-of-the-art methods, including HeMIS [11, 12], U-HVED [11, 13] and RobustSeg [11, 14], our model outperforms HeMIS [11, 12] method in segmenting all tumor subregions. Compared with the second-best method, i.e., RobustSeg [11, 14], our network seems to have a closer segmentation result for tumor core (TC) and whole tumor (WT) subregions. However, this is not a big problem, and our model still outperformed the previous models in terms of edema (ED) segmentation.

In this work, through a proof and error process we obtained the optimal hyperparameters values for our application. We used a batch size of 2 and learning rate of 0.0001 which did vary during the training process according to the change on the validation loss in certain number of epochs. The focal loss was used and achieved a good convergence of the model losses. The model was trained for 200 epochs and a combination of dropout value between 0.1 and 0.2 was used. We employed the Adam optimizer.

VI. CONCLUSION AND FUTURE SCOPE

This paper focuses on both 2D and 3D U-Net architecture, we used the BraTS2020 datasets as a lab for our experiment and the performance of all U-Net models is evaluated with the help of performance metrics Dice similarity coefficient, and accuracy. The results show that the proposed 3D U-Net supersedes and outperforms other proposed methods with a training Dice Coefficient of 86%. However, the methods used in this study had certain limitations. Due to the depth of the network, those models are computationally expensive and time consuming.

In the future work, we plan to improve the segmentation performance in order to make better results and the key for this is data preprocessing along with data augmentation, as the image may hold unwanted data and information which can be detached to solve the problems of tumor cell recognition.

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Testing Open Multi-Agent Systems

1st Djaber Guassmi
Department of Mathematics and Informatics
University of Oum El Bouaghi
Oum El Bouaghi, Algeria
djaber.guassmi@univ-oeb.dz

2nd Nour El Houda Dehimi
Department of Mathematics and Informatics
University of Oum El Bouaghi
Oum El Bouaghi, Algeria
dehimi.nourelhouda@univ-oeb.dz

3rd Mekhlouf Derdour
Department of Mathematics and Informatics
University of Oum El Bouaghi
Oum El Bouaghi, Algeria
derdour.makhlouf@univ-oeb.dz

***Abstract*—Open multi-agent systems (OMAS) operate in dynamic environments with heterogeneous, independently developed agents, presenting unique quality assurance challenges. This paper examines systematic testing methodologies for OMAS, focusing on validation techniques that address openness, scalability, and unpredictable interactions. We propose an integrated testing framework combining simulation-based analysis, evolutionary testing, and ontology-driven test generation. The approach emphasizes adaptability to runtime agent entry/exit and evolving interaction protocols. Experimental evaluation demonstrates significant improvements in fault detection and system robustness compared to conventional testing strategies for closed MAS architectures.**

***Index Terms*—Open Multi-Agent Systems, System Level Testing, Quality Assurance, Evolutionary Testing, Ontology-Based Validation**

I. Introduction

Open multi-agent systems (OMAS) [1], [2] facilitate collaboration among autonomous, heterogeneous agents in decentralized and often unpredictable environments. Unlike closed systems, OMAS permit agents to join or leave dynamically, operate with partial knowledge, and interact without predefined coordination protocols [3]. These characteristics introduce substantial verification complexities, particularly regarding interoperability, security, and emergent behavior validation. This research addresses the critical need for specialized testing methodologies tailored to OMAS characteristics, proposing a multi-faceted verification framework that adapts to system dynamism while maintaining rigorous quality standards [4], [5], [6].

II. Background and Challenges

OMAS testing diverges significantly from traditional software validation due to several inherent properties: (1) agent heterogeneity and autonomy, (2) dynamic membership and ad hoc interactions, (3) decentralized control and partial observability, and (4) evolving communication protocols. These factors necessitate testing approaches that are adaptive, scalable, and capable of handling non-deterministic behaviors. Existing work in closed MAS testing [7] provides foundational techniques but requires substantial extension to address openness-related concerns such as security vulnerabilities [8], [9] and protocol compliance.

III. Proposed Testing Framework

The proposed framework integrates three complementary testing methodologies: simulation-based scientific analysis, evolutionary testing, and ontology-based test generation. This tripartite approach addresses different aspects of OMAS validation, from behavioral emulation to systematic test case derivation.

A. Simulation-Based Analysis

Simulation environments replicate OMAS operational conditions, enabling controlled observation of agent interactions. Following De Wolf et al. [10], we employ agent-based simulation to model dynamic agent entry/exit, message passing, and environmental changes. The simulation generates execution traces that serve as test oracles for validating real-system behaviors.

B. Evolutionary Testing

Evolutionary algorithms generate test cases that maximize fault detection in complex state spaces. Adapted from Nguyen et al. [11], our approach evolves test scenarios using fitness functions that measure coverage of interaction patterns, goal achievement rates, and exception handling. The algorithm iteratively refines test suites over generations:

$$T_{i+1} = \text{select}(T_i) \cup \text{crossover}(T_i) \cup \text{mutate}(T_i)$$

where selection favors test cases revealing behavioral anomalies.

C. Ontology-Based Test Generation

Ontologies formally represent domain knowledge, agent capabilities, and interaction protocols. Following Nguyen et al. [12], we derive test cases by reasoning over ontological constraints. For a given agent capability C and protocol P, the test generator produces interaction sequences that satisfy:

$$\text{Test}(C, P) = \{\sigma | \sigma \models \text{Pre}(C) \wedge \sigma \in \text{Traces}(P)\}$$

where σ denotes a valid interaction trace.

IV. Implementation

The framework was implemented as an extension to the JADE platform. Simulation components leverage MASON library, evolutionary modules integrate ECJ toolkit, and ontological reasoning uses Prote´ge´ with SWRL rules. The system supports automated test execution, result collection, and adequacy reporting.

V. Evaluation

We evaluated the framework using two OMAS case studies: a disaster response coordination system and a peer-to-peer energy trading network. Each system was subjected to the proposed testing methodology and compared against conventional unit and integration testing approaches. Metrics included fault detection rate, test execution time, and scalability with increasing agent counts.

TABLE I
Comparative Test Effectiveness

Testing Approach	Fault Detection	Time Overhead	Scalability
Proposed Framework	92%	38%	High
Unit Testing Only	67%	12%	Low
Integration Testing	78%	45%	Medium

VI. Discussion

The integrated framework demonstrates superior fault detection capability compared to isolated testing techniques. However, the computational overhead remains non-trivial, particularly for evolutionary components. Additionally, ontological test generation depends heavily on the accuracy and completeness of domain models. Future work will focus on optimizing performance through parallel execution and enhancing ontology learning techniques to reduce manual modeling efforts.

VII. Conclusion

Testing open multi-agent systems requires methodologies that address dynamism, heterogeneity, and emergent interactions. The proposed framework combines simulation, evolutionary, and ontology-based techniques to provide comprehensive validation for OMAS. Experimental results confirm significant improvements in fault detection and system robustness. This research contributes to the establishment of systematic quality assurance practices for increasingly prevalent open agent systems in complex, real-world applications.

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Conventional Methods on Feature Extraction in Palmprint Recognition Systems

Ziadeddine Makhlouf
Laboratory of Mathematics, Informatics and Systems
Larbi Tebessi University
Tebessa, Algeria
ziadeddine.makhlouf@univ-tebessa.dz

Lakhdar Laimeche
Laboratory of Mathematics, Informatics and Systems
Larbi Tebessi University
Tebessa, Algeria
lakhdar.laimeche @univ-tebessa.dz

Abdallah Meraoumia
Laboratory of Mathematics, Informatics and Systems
Larbi Tebessi University
Tebessa, Algeria
ameraoumia@univ-tebessa.dz

Mohamed Yassine Haouam
Laboratory of Mathematics, Informatics and Systems
Larbi Tebessi University
Tebessa, Algeria
mohamed-yassine.haouam@univ-tebessa.dz

***Abstract*— Palmprint is relatively a new biometric modality that has known an increase in focus in the research field in the last decade. As with any biometric system, a palmprint recognition system is composed of major steps from the acquisition of the hand data to the matching module. Among these phases, the feature extraction step has a great impact on the accuracy of the results. For that reason, a variety of approaches was introduced to extract discriminative features from acquired images. In our work, we present an overview of these approaches taking into consideration the type of palmprint images and the way they were acquired.**

***Keywords* —** *biometric system, palmprint, contact-based palmprint image, 3d palmprint image, high resolution palmprint image*

I. INTRODUCTION

Historically, identifying individuals was based on what they have and know, i.e., badges, ID cards, and passwords. However, with the increasing need for more secure systems, problems arising from the identification methods mentioned above have proven incompatible with the required reliability and accuracy of these systems. In trying to answer these questions, technology leads us to use the unique characteristics of an individual to identify him or her, which led to the emergence of biometry, defined as "automated recognition of individuals based on their behavioral and biological characteristics." In contrast to traditional methods, biometrics have proven superior in accuracy, robustness, and security. The purpose of biometrics is to transform an individual's biological, morphological and behavioral characteristics into numerical identifiers. Amongst these features (modalities), there is one that has shown promising results: palmprint. Palmprint recognition has gained a lot of interest in the research field in recent years; its robustness comes from the number of unique features processed, including the principal lines and wrinkles and abundant ridge and minutiae-based features.

In our work, we will present palmprint recognition systems and the categories of palmprint images before presenting the methods used to extract the region of interest from a palmprint image, while the methods applied to extract features from acquired images are presented in the fifth part.

II. PALMPRINT RECOGNITION

Palmprint is a relatively new biometric modality, it contains more information than fingerprints, and they are more discriminant. Its superiority against fingerprints comes from the additional distinctive features like main lines and ridges, which can be extracted from low-resolution images. Like all biometric systems, there are five main steps to the palmprint recognition system: image acquisition, pre-processing, feature extraction, matching, and decision as shown in fig 1. In general, a pre-processing step is applied before the feature extraction phase, this process serves to avoid unnecessary information that exists in the original image. The feature extraction process takes the pre-processed image as input and extracts only relevant information in order to create a new data representation (biometric template). It is important to emphasize that the new representation must be unique to each person and relatively invariant.

III. CATEGORIES OF PALMPRINT IMAGES

As in every biometric modality, the palmprint recognition methods are affected directly by the images' characteristics. Because of that, and in order to comprehend the features that will be extracted from those images, it is necessary to clarify their categories. Palmprint images can be categorized based on a variety of criteria:

A. Based on dimensions

- 2D palmprint images: almost all palmprint recognition methods are applied to images of this category, in which the features extracted do not take in consideration the depth information.
- 3D palmprint images [1]: in these images, rather than simply capturing information from the palmprint surface, also depth information is taken into account, which adds more discriminative data.

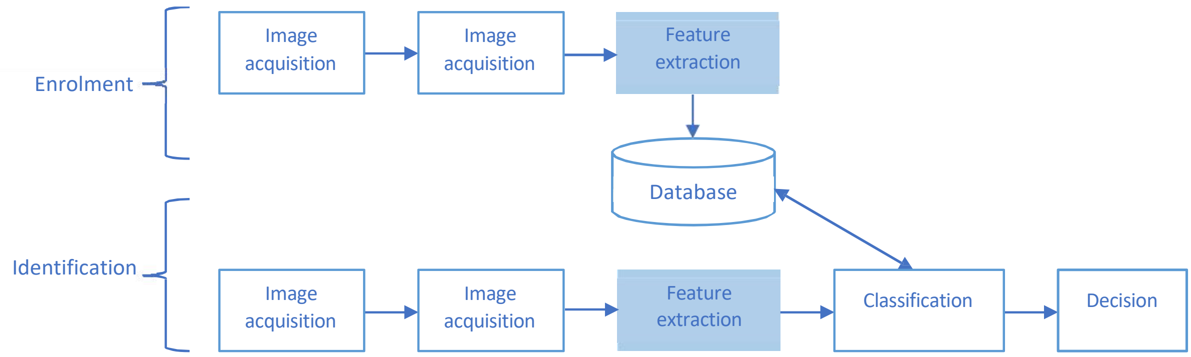

Fig.1. Architecture of biometric system.

B. Based on resolutions [2] [3]

- Low-resolution palmprint images: these images usually have a resolution of around 100 pixel per inch, they may be captured either by the contact-based method or by the contactless method.
- High-resolution palmprint images: in this category, images are mostly taken in a contact-based context, their resolutions are greater than 400 ppi (pixel per inch), which makes palmer friction ridges and palmer friction creases visible.

C. Based on the way of acquisition

- Contact-based palmprint images: in this type, the user's hand touches the capture device, i.e., there is contact between the two parts of the operation. Images captured in this category may be 3-D or 2-D, regardless of the resolution.
- Contactless palmprint images [4]: images taken in a contactless context are usually captured without guidance to the user and with commercial cameras, this means that they are often invariant in rotation, translation, scale and lighting and suffer from greater noise than in contact-based images. It is also more acceptable to users and can at the same time resolve the hygiene issue.

IV. Feature Extraction Methods in Palmprint Recognition

As a result of the increasing attention that palmprint recognition has received, a large number of methods and approaches to feature extraction have been developed and proposed, these methods vary depending on the type of images extracted and the features to be processed. Since contact-based palmprint recognition is the most widely used and easy to implement, it has attracted the most attention in research.

In [5], the authors provided a comparative study on palmprint recognition algorithms, in which they provided the difference Gaussian filter as a sample of local feature-based recognition, meanwhile, in [6] it's shown that using a bank of Gabor filter (generalized Gabor filters) increases the feature extraction capability compared to competitive code, while in [7], the researchers applied a 2d Gabor Wavelets. Oriented multiscale log-Gabor filters were proposed in [8] as another Gabor filter approach, and in [9] a three patch LBP applied on the PolyU data base was presented. The paper [10] has demonstrated that accuracy can be improved in palmprint recognition by applying radon filters, furthermore, [10] and [11] has applied Sobel operation in the feature extraction in a palmprint recognition system. Optimal Stack filters are a robust method for edge detection, which were used in [12]. In contrast to methods based on line feature, [13] approach was based on orientation features and utilized palm code in feature extraction phase, while authors of both [14] and [15] contribution was implemented with competitive code. Binary orientation co-occurrence vector (BOCV) was the contribution of [16], in which, the authors compared the EER with the competitive code (CompCode), palmprint orientation code (POC) [13] and robust line orientation code (RLOC) [17], meanwhile, double-orientation code (DOC) [32] scheme was created in order to represent the orientation feature of palmprint.

Contactless palmprint recognition meets the needs of users, as they don't like to touch acquisition devices, and as a result numerous methods were developed in order to increase accuracy and robustness of such systems despite all their challenges. In [18], it has been verified that Scale-invariant feature transform (SIFT) outperforms other conventional methods in contactless images, in further work [19], the authors proposed SIFT-based method with three main modifications from the traditional SIFT. Since local binary pattern (LBP) has proven high accuracy rates in other biometrics, it was applied in many researches, including [20] and [21], and was combined with weighted sparse representation-based classification (WSRC) in [22]. The authors of [23] created an LBP-like descriptor that operates in the local line-geometry space named local line directional patterns (LLDP) which performed competitively in palmprint recognition. Orthogonal line ordinal features (OLOF)[24] was another approach with the purpose of extracting discriminant features for effective classification in contactless recognition.

High resolution palmprint images are of high value in forensic applications, their resolution is greater than 400 ppi, the feature of a high-resolution image can be categorized in three types, the first is Local Ridge Direction (LRD) in which many representative methods were proposed, like gradient-based method [25] and discrete Fourier transform (DFT) [26]. Minutiae Points is another feature in high resolution palmprint images, in [27], it's shown a method for extracting the coordinate of Minutiae Points. Another feature of high resolution palmprint images that got high focus in research is principal lines, which were extracted using Hough transform in [26] and modified finite Radon transform (MFRAT) in [28].

Due to the completely different information that 3d images contain compared to 2d images, there was an increase in interest in this type of palmprint images in the last decade, in [29], the representative feature extraction schemes were divided into categories, the first are the methods that extract 2d features from curvature-based images like MCI and GCI [30] [31] while the methods that extract feature from 3d surface type were grouped into the second type of methods.

V. ACKNOWLEDGEMENT

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VI. CONCLUSION

Whereas palmprint recognition is a new area compared to other biometrics, it has gained much interest in research, and various methods and approaches have been suggested to improve the efficiency of each phase of the palmprint recognition system. The phase of feature extraction is a key step in the recognition process and it has been the discussed point in our paper, where we have provided an overview of the methods and solutions suggested for each of the types of palmprint images. despite the high accuracy and robustness, the palmprint recognition systems have achieved, there are still some challenging issues that need to overcome like combining conventional methods with deep learning techniques in feature extraction phase, and automatically extract ROI in a contactless palmprint recognition system.

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Self-Adaptation of IoT Systems Using Multi-Agent Systems based on the Semantic Web

Mohamed MAOUI
Department of Mathematics and Computer Sciences
Faculty of Exact Sciences, Natural and Life Sciences
Larbi Ben M'hidi University – Oum El Bouaghi
Oum El Bouaghi, Algeria
Email: mohamed.maoui@univ-oeb.dz

Rohallah Benaboud
Department of Mathematics and Computer Sciences
Faculty of Exact Sciences, Natural and Life Sciences
Larbi Ben M'hidi University – Oum El Bouaghi
Oum El Bouaghi, Algeria
Email: r_benaboud@yahoo.fr

***Abstract*—In software-intensive systems, specifically Internet of Things (IoT) systems, software applications (called IoT applications) are composed of a set of services and software that can analyze and present the data transmitted by the various IoT devices. These IoT applications operate in highly dynamic and heterogeneous environments that cause uncertainties that are difficult to anticipate before their deployments. It is therefore crucial that these uncertainties are resolved at their runtime, when the missing knowledge becomes available, in order to adjust their behavior in response to the dynamics of their environments, in other words, they need to be *self-adaptive*. In this context, agent-oriented software engineering and multi-agent systems (MASs) will be of paramount importance, as they can adapt their behavior at runtime in response to events that may not have been fully anticipated. Furthermore, regarding knowledge management and its use to coordinate agent behavior, new standards of the Linked Data and the Semantic Web are considered. This paper presents a brief overview of what constitutes a self-adaptive system by introducing the most influential reference control model for these systems, called MAPE-K (Monitor, Analyze, Plan, and Execute, with a Knowledge Base common). It also seeks to contribute to the evolution of this research area while proposing an approach based on MAS and Semantic Web standards.**

1. Introduction

In the last decade, technological progress has allowed the miniaturization of computer equipments, while integrating them more advanced functionalities. This technological progress is the basis for so-called "software-intensive" systems which are, by definition, any system where software influences to a large extent the design, construction, deployment, operation, and evolution of the system as a whole [1] [2] [3].

In this context, it is worth mentioning in particular the "connected world" systems (see Fig. 1), often referred to as the "Internet of Things (IoT)" systems [4] that are based on an insolent interconnection of communicating objects via the Internet, both among themselves and with any other device that has the ability to connect [5]. The software applications in these systems (also known as *IoT applications*), are constituted from a collection of services and software with a potential to operate continuously under *uncertain conditions* to integrate the data collected by the communicating objects, or transmitted by other IoT devices[1] – whose availability evolves in time and space [6], and very often in a totally unexpected way. The IoT applications must therefore have some capability to resolve these uncertainties in order to reason about themselves and, depending on their objectives, dynamically adapt to changes induced by the problems of their environment to preserve their quality requirements or to degrade gracefully if necessary, that is, they must be *self-adaptive* [3] [7] [8].

According to [3] [9], this self-adaptation capability is essential to ensure the consistency of IoT applications with the environment in which they operate, and it is traditionally built using a simple sequence of activities - namely *monitor*, *analyze*, *plan*, and *execute* (MAPE) - [11] that share various models with each other by means of what is termed *knowledge* (MAPE-K) [9] [10] [11] [12] [13] [14]. Together, these activities form a *feedback loop* [10] [11] as depicted in Fig. 2.

However, as these applications increasingly integrate heterogeneous environments, due to the fact that they are more and more interconnected and diverse [14], their engineering is challenged, as it requires new concepts, new approaches, new architectures, new communication and cooperation processes [7] and supporting infrastructures [3].

The next part outlines the motivations behind the search for a new approach for better self-adaptation of IoT applications. The third part details the objectives of the research. Finally, the fourth part describes the research methodologies that were applied.

1. https://aws.amazon.com/what-is/iot/.

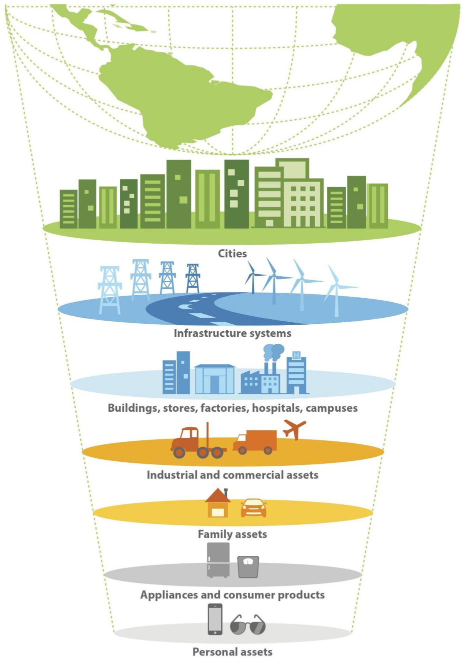

Fig. 1. Connected world systems from the "macro" to the "micro" © 2013 Forrester Research, Inc. [4].

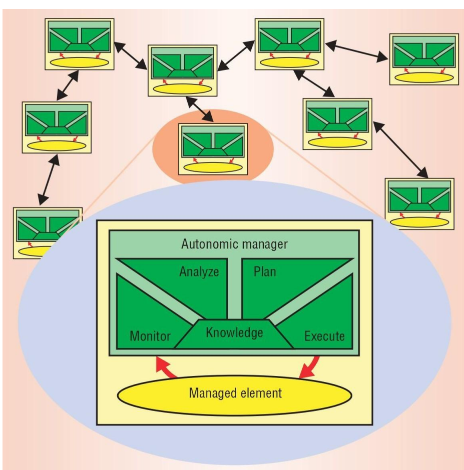

Fig. 2. The MAPE-K model © 2003 IEEE [14].

2. Motivations

As previously explained, IoT applications are becoming increasingly heterogeneous and complex [14] and, as a result, resolving uncertainties in the operating conditions of an IoT system - whose possible causes: instability within the operating environment, evolution in the availability of resources and changes of user goals - is an increasingly important challenge for software engineers given the difficulties that arise during operation (difficult to manage by system operators), on the one hand, and prior to deployment (difficult to anticipate) on the other. Such difficulties can hinder the realization of IoT system requirements. In light of this, a consensus has emerged that self-adaptation of IoT applications is strongly recommended to solve the problems that cause these uncertainties [3]. Thus, IoT applications possessing this self-adaptation capability are generally referred to as *self-adaptive IoT applications*.

3. Objectives

Self-adaptation of software-intensive systems is a remarkable research area where several academic[2] and industrial[3] efforts have proposed different approaches to support its development process. The basic idea is to let the system self-adapt during its execution in the image of traditional approaches, which include autonomous systems, multi-agent systems (MAS), self-organizing systems, and context-aware systems [3]. However, little attention has been paid to knowledge management between software applications in these systems.

This research work aims at proposing a new approach to ensure the effectiveness of self-adaptation capability within software-intensive systems in general, and within IoT systems, in particular. It is a hybrid approach based on MAS, due to their remarkable characteristics, namely efficiency, reliability, flexibility and low cost [15] [16], while introducing the possibilities offered by the new standards of the Linked Data and the Semantic Web for the management of knowledge between agents [17] [18].

4. Research methods

4.1. Selection of publications

Our research was conducted in five distinct steps defined as follows:

1) Definition of the research questions;
2) Identification of relevant publications;
3) Assessment of the quality of the publications;
4) Reading the selected publications while taking notes on the main points addressed;
5) Interpreting the notes.

All these steps were followed with the objective of answering the following questions:

- Q1: *How is a self-adaptive system designed?*
- Q2: *How to manage knowledge using the new standards of the Linked Data and the Semantic Web?*

2. DeltaIoT exemplar developed by imec-DistriNet research group is a typical exemplar of a self-adaptive IoT application. Detailed information on this exemplar is available at https://people.cs.kuleuven.be/~danny.weyns/software/DeltaIoT/.

3. In 2001, International Business Machines Corporation (IBM for short), published a manifesto referring to an impending crisis of software complexity in the IT industry. About 5 years later, it proposed an architecture for autonomous systems using MAPE-K feedback loops.

4.2. Research sources and strategies

The research was carried out on French and English language publications available online from electronic documentary databases:

- IEEE *Xplore* (https://ieeexplore.ieee.org/Xplore/home.jsp);
- SpringerLink (https://link.springer.com/);
- ISTE OpenScience (https://www.openscience.fr/Accueil);
- WILEY (https://www.wiley.com/en-gb);
- HAL (https://hal.archives-ouvertes.fr/);
- ResearchGate (https://www.researchgate.net/);
- Google Scholar (https://scholar.google.com/);
- Forrester Research (https://www.forrester.com/report/).

First, the publications were researched according to the keywords defined in Table 1. By studying the titles of the returned publications, we were able to retain the most relevant publications. The reading of these publications was useful to determine a starting point to become familiar with the field of self-adaptation. Finally, this third step allowed us to discover [3] which aims to provide a solid foundation for anyone interested in self-adaptation to acquire the knowledge and skills necessary to understand the elementary principles and engineering methods of self-adaptive systems.

Theme	Keywords
Self-adaptation of IoT systems using MAS	("Self-adaptation") AND ("IoT Systems" OR "IoT Applications" OR "IoT Architecture") AND ("MAS")
Knowledge management in an IoT system	("Semantic Web" OR "Ontology") AND ("IoT Systems" OR "IoT Applications" OR "IoT Architecture")
Semantic web for MAS	("Semantic Web" OR "Semantic") AND ("MAS")

TABLE 1: Terms used for the research.

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SMART ENERGY MANAGEMENT

1st Mohamed Salah BENKHALFALLAH
dept. Mathematics and Informatics
Larbi Ben M'hidi University
Oum El Bouaghi, Algeria
mohamedsalah.benkhalfallah@univ-oeb.dz

2nd Sofia KOUAH
dept. Mathematics and Informatics
Larbi Ben M'hidi University
Oum El Bouaghi, Algeria
sofia.kouah@univ-oeb.dz

3rd Samira CHEBBOUT
dept. Mathematics and Informatics
Larbi Ben M'hidi University
Oum El Bouaghi, Algeria
chebbout_info@yahoo.fr

***Abstract*—This paper deals with smart energy management in the context of Smart City, which is seen as a new urban development concept that aims to improve the quality of life of city dwellers by making the city more adaptive and efficient. It automatically monitors and reduces sustainable energy consumption, especially during peak hours, improves asset performance, identifies and reports problems, detects equipment failures before they occur, and contributes to smart energy management. This work aims to provide a brief overview of such field and states the main goal to pursue in our research.**

***Index Terms*—Artificial Intelligence, Machine Learning, Deep Learning, Internet of Things, Smart Energy, Smart City.**

I. Introduction

In recent years, Internet of Things (IoT) has been one of the most important technologies of the 21st century, now it will not only be confined to the scientific and technical areas of life, but will gradually spread to become an essential part of our daily lives. In the world of technological revolution in which we live, IoT is helping people to live and work smarter, as well as to have full control over their lives and property. Besides being a major contributor to connecting smart devices to automate and manage urban cities, it is extremely vital and necessary for businesses, enterprises and factories [1].
In short, the Internet of Things is the natural evolution of the networking approach that aims to make the real world smarter by connecting things. It is not a single computer program or device or a specific type of technology, it is an overall concept that involves the integration of several devices, software and networks to achieve the desired results. Its integrated system consists of five main components as follows [2]:

- *Objects or devices (Sensor Module)*: These are equipped with sensors and actuators. The sensors collect data from the environment and transmit it to the gateway where the actuators perform the action.
- *Gateway*: The sensors provide data to the gateway and here a kind of pre-processing of the data is even done. It also acts as a security layer for the network and for the transmitted data.
- *Cloud*: Data after being collected is uploaded to the cloud. Which is essentially a set of servers connected to the internet 24/7.
- *Analytics*: The data after being received in the cloud, the processing is done. Various algorithms are applied here for proper analysis of the data.
- *Interface*: end user application where the user can monitor or control the data.

IoT will become routine, natural and indispensable, among the most famous fields of its application we mention: the field of industry, agriculture, business, health, energy, transport, sports, pharmacy, nutrition, pharmaceuticals, automotive, security, smart city, smart home, wearable technologies, environmental, infrastructure, roads, device management, luxury, comfort, and all public services.

This work falls within the framework of the **Smart City** (digital city or eco-city), considered as an innovative city to improve the quality of life, make urban operations and services more efficient, strengthen its competitiveness, and enrich energy efficiency and waste management while ensuring that it meets the economic, social, environmental and cultural needs of present and future generations. It relies on a stable, secure, reliable and interoperable communications infrastructure to support a huge volume of Information and communication technologies-based applications and services that in turn reduce energy consumption, help reduce environmental pollution and improve a wide range of urban activities and businesses. It is also driven and supported by the Internet of Things, artificial intelligence, digital twins, robotics, smart grids and smart meters [3].

Our work focuses on **energy management**, which according to the international standard ISO 50001-2018, is considered to be a systematic approach to improving energy performance and can provide additional economic benefits for companies and communities. It also offers an immediate and easily quantifiable return on investment [4].

II. Research challenges & Literature review

In this regard, several challenges arise, among others: massive urbanisation, ensuring that the collection, monitoring, analysis and evaluation of energy data is an interactive and continuous process where accurate and manageable energy monitoring is the basis for meeting energy management requirements, flexibility in the ability of power plants to respond to changing electricity consumption patterns especially in its increase during peak hours, reliability is that the power supply is continuous, uninterrupted, of good quality and adaptable

to unforeseen environmental events (fighting climate change), economy of exploitation of this energy, and the technical challenge of obsolescence of smart objects [5].
In the literature, several related works have been proposed, such as:

- Building a low carbon city by using the digital version of the digital twin to reduce energy consumption while maintaining or increasing the current widely understood level of economic activity [6]. This work is based on: Digital Twin, Internet of Things, Big Data, and Cloud com-putting [6].
- Investigating the HEMS (Home Energy Management System) architecture integrated with SG (Smart Grid), including HEMS functionality, SG renewables, the central console of the smart energy management system, smart appliance classification, the most advanced HEMS monitoring devices, sensors and meters, and the HEMS communication and networking system [7]. This work is based on: Home energy management system, Smart grid, Home energy storage system, Optimization scheduling techniques [7].
- Investigating economic performance factors and determining energy protection needs for an efficient energy management in smart cities which is based on active and passive models. Moreover, for infrastructure advancements, considering lower energy management in intelligent cities defined by intelligent street lighting (using LED) [8].
- In [9], authors have provided an analysis of the smart home energy management system in order to identify current trends and challenges for future improvement. The result reveals a lack of quality attributes such as security, privacy, scalability, interoperability and difficulty in managing and adapting to meet the population thermal comfort, exposing them to health risks. They described opportunities for future research that ensure energy efficient smart homes, free from unnecessary energy consumption, health problems and cyber security attacks.
- In [10], authors have studied electricity cost for residential end-users due to the integration of distributed photovoltaics and electrical energy storage. The formulation of Home Energy Management problem has been specified by means of reinforcement learning strategy based on Q-value and taking into account the priority of the end users. In addition to reducing the cost of energy consumption and improving performance.
- In [11], authors have Highlighted the need to pay attention to non-smart devices and propose a solution to integrate these devices into energy-efficient IoT space, which is Homergy, a smart IoT-based home energy management solution that is useful for any advanced and developed market. It consists of an IoT devices with internet connectivity, an embedded microcontroller and opto-coupled relays, a cloud-based NoSQL database with streaming capabilities, and a secure cross-platform mobile application. Thus, a modular IoT-based home energy management system has been successfully developed, giving users the ability to control power consumption of their devices.

One can observes that these works address numerous issues and deal with different kinds of energies, also, they use various paradigms and techniques.

III. Problematic & Objective

In our work, we are mainly interested in how combining unexpected environmental events and constraints, information and communication technologies, as well as the IoT and artificial intelligence paradigms in order to provide intelligent energy management with high and advanced efficiency and energy consumption rationalization. Thus, we aim at proposing a smart energy management strategy to fulfil such challenge.

In fact, in recent years, with the tremendous development of technology, the technique of artificial intelligence has become an important strategy to automate processes, tasks, human actions or decisions [12] [13] [14]. We should probably contemplate Deep Learning to provide an efficient smart energy management strategy.

IV. Discussion and Outcomes

In order to establish a consistent comparison between the presented works and other related ones, we have to make, at first time, a choice of which kind of energy should we study and the most relevant criteria that impact energy consumption and management. This makes subject of a current work which aims at providing a rigorous review of existing works that are founded on IA, IoT and newest technologies such as Cloud computing, Edge and Fog computing. Regarding energy indicators, The energy management system, as suggested by ISO 50001, provides a definition for a range of energy indicators, including : Plan Do Check Act (PDCA) for Energy Management: adopting continuous improvement in the PDCA cycle, which is the main activity driving the improvement areas, Case study DATA CENTER KPI Specifically for data centres, three performance indicators were used: Comparison with the international standard (called PUE - force of use), customer reality by IT equipment power (dimensionless) and IT power (R$ /kWTI), Case study on Key Performance Indicators (KPIs): Choosing an appropriate set of KPIs and carefully checking the obtained values is an exciting and investigative work [4].
Some factors that also impact energy consumption are: Weather variations, Time changes, Economic activity, Preferential tariffs as contractual incentives, Eco-citizen campaigns, Changes induced by occasional events.
With these indicators we can know and rationalise our energy consumption, thus establishing good energy management [4].

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Use of artificial intelligence and optimization techniques to improve health services

Karim Bechiri
Computer science and its application department, LISIA laboratory, NTIC faculty, University Constantine 2 - Abdelhamid Mehri
Constantine, Algeria
Karim.Bechiri@univ-constantine2.dz

***Abstract*— Home health care (HHC) has widely been implemented in many countries in recent years. Effective management of this new kind of health services is essential for its success, and current issues of hospital environment require rethinking of organization, planning, and optimization. The home health care routing and scheduling problem (HHCRSP) is a challenging operational problem in the field of HHC. Several approaches based on the Vehicle Routing Problem (VRP) have been suggested. Yet, several constraints remain unaddressed by the present solutions. In this paper, we suggest an efficient routing solution for caregivers' vehicles while taking into account the growing complexity and specific constraints related to the HHCRSP problem.**

Keywords*— *Metaheuristics, Combinatorial optimization, Artificial intelligence, Machine learning, Planning, Home health care, Vehicle routing problem, Emergency.

I. Introduction

Good citizens' health has a direct impact on welfare state and economic progress. With the growth of the population and the lengthening of the average life expectancy in recent years, the difficulty of managing health services has become increasingly serious. The use of limited resources has sparked further management difficulties, particularly with the new expanded hospital structure due to the emergence of Home health care (HHC).

Defined as the continuity of hospital care services given to patients directly in their homes in case of injury [1], illness, or incapacitating condition, the HHC will assist in ensuring and maintaining patients' independence for a long time [2]. As HHC has become very popular in recent years, rigorous resource management is necessary to ensure its effectiveness, involving medical, paramedical and social teams. A sound management of the aforementioned actors requires a comprehensive planning and scheduling, which makes the focal point of the present paper.

In many countries, HHC service planning is still made manually by a few experienced managers [3]. However, comprehensive and efficient planning is extremely challenging with the emergence of increasing constraints.

The challenge is to build a decisions making model that fulfills the patient's request while planning the activities of all concerned teams. Comprehensive and optimal cost and time planning of activities involves several constraints that need to be addressed to ensure high-quality services [4]. This planning is also known as the home health care routing and scheduling problem (HHCRSP) [5]. The use of vehicles to transport medical professionals from hospitals to patients' homes is regarded as a routing issue

When the caregivers are described as vehicles, the HHCRSP is considered as a version of the vehicle routing problem (VRP) [5].

To improve the quality of service and guarantee the patient's satisfaction, accommodating the availability of the patient's preference makes another planning constraint that is not easy to address. This variant is VRP with time windows (VRPTW) [6], with time windows (TW) being an interval in time during which a patient is available to receive care service.

Another variant present in the VRP family problem is when caregivers depart from different locations and use private cars, causing multi-depot vehicle routing problem (MDVRP) [7].

Therefore, the two aforementioned variants may be assimilated to multi-depot vehicle routing problem with time windows (MDVRPTW). Many other severe constraints are present in this HHC management, including the lunch break (LB) and synchronized visits (SV). For the former, if certain requirements are met, the caregiver is authorized to have a mandatory lunch break [6]. For the latter, some patients might require many caregivers at once, (e.g. two people are required to transfer the patient from bed to wheelchair) [8]. All these described constraints may be combined, and further ones may be added, making, therefore, reaching an optimal solution a hard task.

In this paper, we present a review of literature in section II, research problem and objectives in Section III, and Section IV concludes with the idea to explore, the methodology and expected outcome.

II. Literature review

Since our research problem is an extension of the classical VRP problem and its variants, we will start reviewing VRP literature, followed by a related research on the HHCRSP.

The HHC planning has been proven to be a combinatorial optimization problem belonging to the class of the NP-hard problem [9]. A significant amount of research has been done during the last decade focusing on routing optimization problems. The traditional traveling salesman problem (TSP) is the most basic routing issue. A salesman must travel to several cities, then they must drive back to the first location they have visited while minimizing the total traveling distance [10]. The Vehicle Routing Problem (VRP) is the m-TSP, where each city has a demand (sometimes referred to as a client) and each vehicle has a specific capacity [11]. The VRP changes to VRPTW if we give each consumer a time window. VRPTW has been widely applied to bus, bank, and postal scheduling [9].

Numerous algorithms have been developed over the past few decades to solve the VRPTW. These algorithms can be categorized into two groups: exact approaches and approximate algorithms.

The exact methods can ensure optimality, however, this approach is limited to solving problems with small instances since the complexity increase quickly for large-scale instances and computing times are too long to be accepted. Like the Lagrange Relaxation Method, Branch and Bound, Branch And Cut [11], and others mixed-integer programming (MIP) solvers. A deterministic model with CPLEX solver is used for HHCRSP [2].

Heuristic and metaheuristic algorithms are able to find approximately optimal solutions in an acceptable time without guaranteeing the optimality of the solution. The heuristic is mainly based on the characteristics of a specific problem, while the metaheuristic is a general-purpose algorithm and can be used in a wide variety of optimization problems, like genetic algorithms (GA) for HHCRSP [2], and MDVRPTW [7], Simulated Annealing (SA) for VRPTW SV [12].

Hybridization of two or more algorithms is used in HHC context, combining the advantage of each approach. A hybrid GA is proposed in [12] to solve VRPTW. Four hybrid meta-heuristics are proposed in [6], hybrid SA (HSA) that combines SA with the ability of stochastic search and LS to intensify the solution, hybrid genetic general variable neighborhood search (HGGVNS), and other algorithms for HHCRSP with TW, LB and SV constraints. Exact methods can also be combined with heuristics or metaheuristics, like an efficient approach for larger problem instances with the integration of the Gossip algorithm with a local solver based on Column Generation [13].

In the last years, artificial intelligence (AI) has emerged as a major developing field, and its efficiency has been proven in a variety of areas. Recent research combines AI methods and classical optimization to improve VRP planning. Machine learning is used with Branch and Price to acquire knowledge during optimization runs, that can be used in future algorithm calls, like the human ability to recognize patterns based on previous experience [14].

Reinforcement Learning (RL) shows competitive results by training a single policy model that finds near-optimal routing solutions, only by observing the reward signals and according to feasibility rules [15]. Article [16] highlights the potential of RL using fully connected neural network approximators of the action-value function in real-world decision-making processes, particularly in the HHC personnel management context.

Using a deep RL (DRL) a trained Agent with previous instances, and improved with reward mechanism is able to generate relatively good feasible solutions to the problem by taking successive actions, with the ability to adjust quickly to any stochastic change in components problem in Electric Vehicle Routing Problem with Time Windows EVRPTW, especially in large sizes instances [17]. RL using a two-phase solver with geometric clustering outperforms or is comparable to the best-known heuristic methods for deterministic and stochastic demand [18].

III. Research Problem And Objectives

Research has suggested feasible solutions in state-of-the-art VRP and HHCRSP, including a set of variants. However, with the expanding complexity, routing planning is still challenging. Our research is based on planning and scheduling problems and efficient resources use in health institutions. We aim to build a decisions making model for planning the activities of all concerned teams. Our suggested model provides a realistic, effective routing solution for caregivers' vehicles that

- satisfies patients' regular requests or urgent home interventions (emergency);
- meets problem-related constraints (e.g. Workload limitations for caregivers' [19]);
- identifies and encompasses emerging constraints;
- minimizes travel time;
- minimizes waiting time (if TW constraints are respected, caregivers' could wait for next patient care);
- reduces associated costs;
- improves the quality of services including patient satisfaction;
- adapts and reschedules intelligently to unexpected events and uncertain situations (real-world stochastic variables).

The typical HHCRSP scenario, as an illustrated example in Fig.1, involves many patients and caregivers distributed in different determined locations. To receive care correctly, each patient has many requirements such as availability preference cited previously as TW, needed caregivers (type or skill level and number in some cases where patients might require many caregivers at once), and finally the emergency level request (urgent or not urgent). Each caregiver's type or skill level is also specified.

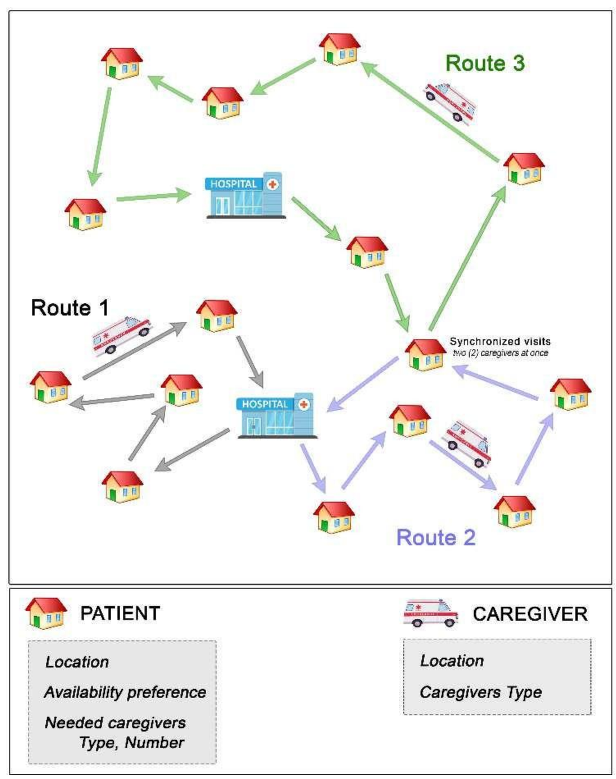

Fig. 1. Example of HHCRSP scenario

Like any optimization problem, we have to identify the metrics such as travel time, distance, and cost, including energy consumption and the number of needed vehicles.

The mathematical model of the objective function is not defined yet, but we can formulate it simply as follows:

Minimize *(travel time) for all scheduled routes.*

If we add patient availability preference, the objective function becomes:

Minimize *(travel time + waiting time) for all scheduled routes.*

Under constraints:

- *Caregivers' Workload limits for any routes*
- *Do not exceed max available vehicles*
- *Respect patients' TW preference*

In an emergency scenario, regardless of the optimization metrics, the routing algorithm must prioritize intervention order to the urgent case (reducing response time is the most important).

IV. Idea To Explore And Methodology

First, we explore the usability of data mining or ML techniques in patients' data history records for forecasting future planning, like predicting availability preference and serving time by analyzing patient behavior.

The accuracy and reliability of travel time from one location to another is critically important for route planning. In the real world, several variables affect this metric, such as weather, traffic, departure time, etc. Based on historical data traffic information, another interesting idea to explore is predicting travel time and energy consumption with ML techniques. Recent research provides good results with relatively small error [20].

Additionally, it is very interesting to explore a new approach based on mixed artificial intelligence methods (RL or DRL) and metaheuristics algorithms, since both methods are more scalable and have proven their effectiveness to achieve near-optimal solutions in a short time, especially in a dynamic environment.

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Nour El Houda DEHIMI *is Assistant professor of Computer Science at the Department of Computer Science and Mathematics at the university of Larbi Ben Mhidi of Oum El Bouaghi. Her areas of interest include mutli agent systems, software engineering, test multi agent systems, machine learning and Deep learning, security and cryptanalysis.*

Makhlouf DERDOUR *is a full professor at the university of Oum Elbouagui and team leader of pervasive systems in the LRS Laboratory of University of Annaba. He received his Ph.D. in 2012. He is now working on wireless networks and Architecture for Distributed Multimedia Applications with QoS management. His research interests include software architecture, multimedia, adaptation, modeling systems, Blockchain and security.*

Djamel BENMERZOUG *is currently a full professor in the department of TLSI, Faculty of New Technologies of Information and Communication, University Constantine 2, Algeria. He holds a PhD in Computer science from Pierre & Marie Curie University (Paris - France) and UMC University (Constantine - Algeria), respectively. His current research interests include Internet of Things, Cloud Computing, Advanced Enterprises Systems, Multiagent Systems, Service Oriented Computing, and Business Processes Modelling and Verification.*

Abdelkrim BOURAMOUL *is a research professor at the Computer Science Department of the Faculty of New Information and Communication Technologies at Constantine 2 University. He is also a founding member of the MISC research laboratory at the same university. He obtained his PhD in computer science jointly from the University of Paris 11 and Constantine 2 in 2011. His research interests include the areas of: Artificial Intelligence, Affective Computing, Virtual and Augmented Reality, Information Retrieval and Visualization in a Big Data context.*

Mohammed Mounir BOUHAMED *received his Ph.D. from the University of Abd El Hamid Mehri, Algeria. His research area includes artificial intelligence, formal methods, and service computing.*