A Review of Medical Image Techniques and Methods based on a Multi-agent System

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Abstract **– In cases where the success of artificial intelligence (AI) approaches is more focused on the multi-agent system (MAS) than those that may make AI understandable to humans, in light of the repetitive cycles of the history of AI, we expect to see technology reevaluation that is commonly referred to as 'classical IA' – especially agent and MAS – in the upcoming years. Other than that, agents and multi-agent (MAS) systems are crucial to designing intelligent systems from the start. They can open new possibilities to researchers for explanatory and intelligent systems through their long-term link with logical technology, which is characteristic of its early times. That is why it is now crucial to comprehend the present position of MAS for medical image methods. This paper thus seeks to provide a complete overview by reviewing the MAS and the agent approaches. Two different views are taken and assessed for the resulting technologies: the MAS and the image processing technologies.**

Keywords **– Intelligent Image processing, multi-agent system, medical image.**

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1. Introduction

For the last decade, both Academia and practitioners have been fascinated by the issue of agent and multi-agent systems (MAS). This happens due to a variety of factors, including pressures from multiple stakeholders and aspects from diverse methodologies, particularly in the field of computer vision research.

Although there is no universal definition of an agent, all definitions agree that it is a specific software component with autonomy that offers an interoperable interface to any system and/or functions like a human agent, working for certain customers and pursuing its own agenda. Even while an agent system might be built on a single agent functioning inside an environment and communicating with its users if necessary, they are commonly made up of numerous agents [1].

These MAS may be used to represent complex systems and incorporate the potential of actors with shared or conflicting agendas. These agents may interact with one another either indirectly (by acting on the environment) or directly (by interacting with each other) (via communication and negotiation). Agents may choose to work together for mutual gain or compete to further their own goals [2].

Agent abstraction is used to frame many distinct artificial intelligent methodologies as a conceptual architecture, and MAS abstraction provides the sound foundation for intelligent system design. In addition, MAS programming languages, technologies, methods, and tools are the most effective for solving medical image problems and real-time image compression, which is the source of sound technologies and methodologies for intelligent systems applications in the computer vision area. Computer vision can use MAS to work appropriately in medical images, improving technical skills, technological preparedness, and process automation possibilities in order to handle unstructured data, context-aware computing.

In all computer vision qualities naming the medical image, image annotation, image segmentation MAS's have the power can overcome implementation and performance issues [3]. The inclusion of MAS in process automation delivers significant advantages [4].

The present study concentrates on the Agent and MAS in the medical image since it is one of the most successful methods of constructing intelligent and autonomous systems that can be understood and explained. More specifically, given the inevitable pushing towards MAS in the field of computer vision, the status already in use in intelligent systems approaches is represented by accessible image processing technologies.

2. Conception of Agent

The intelligent agent is an autonomous computer system with a clever technique for solving complicated environmental problems. Any agent interacts with the environment through a cycle of agent life that implies it observes, decides, and acts. The modern approach to MAS was developed to address the most intricate problems which a single intelligent creature cannot resolve. Although every agent has an individual point of view and local control to resolve the problem separately, all the agents' decentralized data and processing in the agent society are characteristics of MAS. An agent can be thought of as sensing its surroundings through sensors and acting on them through effectors. The organs of a human-like eye, ears, etc., act as sensors for human agents, while mouths, hands, and other body parts can be considered as effectors.

Sensors are replaced with cameras and infrared range finders, and effectors are replaced by different motors in a robotic agent [5]. Figure 1 depicts the basic concept of an agent. The concept is that the sight function symbolizes the agent's capacity to perceive its surroundings, while the action function represents its decision-making process. Action is a function of mapping environmental conditions to percepts.

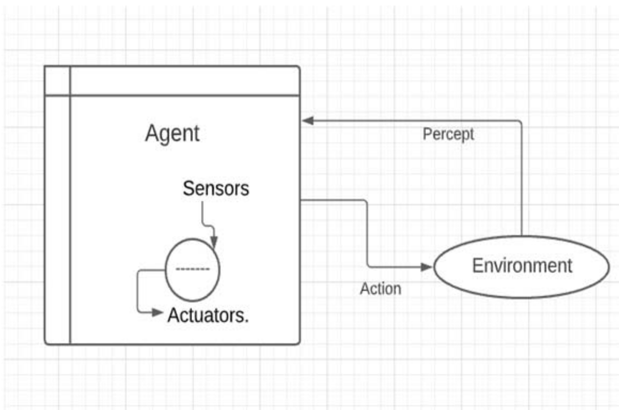

Figure 1. The basic idea of Agent

2.1. Properties of Agents

An agent is autonomous if it functions independently of humans or other entities and has complete control over its actions and internal state. Because it collaborates with people or other agents to complete its tasks, it is social. An agent is adaptable because it detects its surroundings and responds to environmental changes on time. It is proactive because it does not simply respond to its environment but can exhibit goal-directed behavior by taking. Figure 2 shows the main characteristics of the agent [6]. Figure 2 shows the main characteristics of the agent.

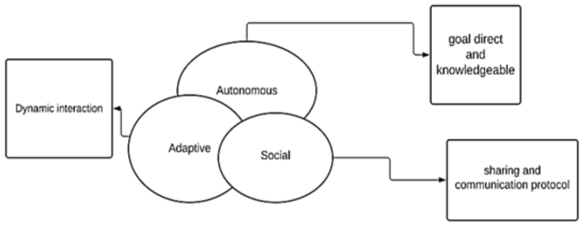

Figure 2. Primary Properties of the agent.

2.2. Agent Architectures

Agent architectures are basic structures that facilitate effective behavior in natural, dynamic, and open environments underlying autonomous components [7]. Agents are defined by several characteristics: location, autonomy, adaptability, communication, distribution, and openness. These characteristics express what people think they need and can do to overcome. Distributed artificial intelligence difficulties and Agent types are shown in Table 1.

Table 1. Agent types

Name Type	Description
Simple reflex	Agents are reactive and frequently consist of a basic rule-based framework that matches sensory inputs to an actuator response.
Model-based reflex	Agents are reactive, and the game imparts a more fundamental understanding of environmental influence while still utilizing some form of the conditional rule base.
Goal-based	Agents must see how different actions affect outcomes to attain the desired goal, distinguishing between goal and non-goal states. Changes the decision-making perspective to make the concept of a goal more accessible; It is possible to have proactive features**.**
Utility-based	Ascribes a sense of utility or perceived value, to any potential state, allowing more prosperous and more flexible interaction with the environment but necessitating the development of ways to assign utility to all possible states. Proactive features are conceivable

2.3. Agent and Environments

The agent might also modify the environment in which an agent's behavior is impacted. They often consider the environment as the factor that impacts an agent; however, in this case, the influence is reciprocal. An environment is anything in the world surrounding the agent that is not a part of the agent. They may define the environment as anything that surrounds yet is separate from the agent and its behaviors. This is where the agent lives' or operates and provides the agent with something to sense and somewhere to move around [8]. Table 2 illustrates the agent environment properties.

Table 2. Agent Environment Properties

Environment	Properties
Accessible versus inaccessible	The agent may acquire complete, accurate, and up-to-date information on the state of the environment in an accessible setting. In this sense, most real-world surroundings are inaccessible.
Deterministic versus non-deterministic	A deterministic environment in which each action has a single guaranteed outcome. There is no ambiguity about the state that will arise from that action; alternatively, it is a non-deterministic environment.
Static versus dynamic	A static environment is one in which the agent's activities are the only thing expected to change. On the other hand, a dynamic environment has other processes acting on it and so changes in ways that are beyond the agent's control.
Discrete versus continuous	An environment is discrete if there are a fixed, the finite number of actions and percepts in it; otherwise, it is continuous.

3. Multi-agent Systems (MAS)

A multi-agent system is a fully integrated system with several intelligent agents engaging with one another to achieve a set of goals or complete a set of tasks. An agent is software that takes autonomous, logical, or preset actions to help a system achieve its goals. These agents have self-contained capabilities, including autonomy, scalability, flexibility, and the ability to solve complicated system difficulties as a group [9]. MASs have this capability because these agents, or intelligent and autonomous units, work together to meet the system's overall requirements [10]. Agents are kept up to speed on the system state and have complete control over their internal status, behavior, and actions. Classification of multi-agent systems based on their characteristics is shown in Table 3.

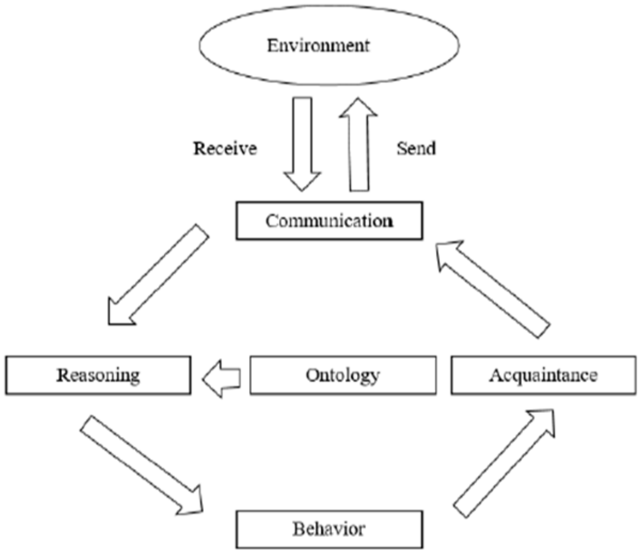

Figure 2. Operation of a multi-agent system

Table 3. Characteristics in MAS

Characteristics	Description
Hierarchy	AMAS agents can define objectives and goals for the other agents in the MAS. It might be regarded as an agent's leadership quality. We can identify two sorts of MAS's based on this attribute. There are two types of MASs: leader-follower MASs and leaderless MAS. The process of other agents is immediately affected by the leader agent following MAS. In leaderless MAS, each agent has decision-making authority and can perform independent activities to meet design goals.
Linear/Non—linear decision function	The variation of MAS's decision function output with input parameter modification can categorize MASs. The output of a decision function is classified as linear if it is proportional to the input fluctuations from the environment, and it can be easily examined mathematically. The judgments made by non-linear MAS are not proportional to the environmental input parameters.
Communication	Agents in MAS can communicate with one another using bidirectional communication channels. Data or information communication might be triggered by an event or by the passage of time. In time-triggered MASs, the agents continually collect data from sensors, process it, and share it with other relevant agents at pre-determined times. Agents in event-triggered MAS only communicate when a specific

	environmental change occurs or when a scheduled activity is completed.
Topology	The topology of MASs can also be used to classify them. Agent locations and inter-agent connections differ. Static and dynamic topologies are the two most common forms. In static topology, an agent's interactions with other agents remain constant, and its placement in the environment remains constant. However, in a dynamic topology, the placement of agents in the environment changes overtime to make their interactions and communication patterns with other agents.

Based on the previous table, it can be summarized accurately in Table 4.

Table 4. Feature Categorization in MAS

Feature	Categorization
Hierarchy	▪ Leader-follow ▪ Leaderless
Decision	▪ Linear Decision Function ▪ Non-Linear Decision Function
Communication	▪ Event triggered ▪ Time triggered
Topology	▪ Static agents ▪ Dynamic agents

3.1. MAS Applications

The importance of providing quick and powerful computing and simulation tools, such as artificial intelligence, in current complex systems to deal with the significant data problem is of special sign cancel. This shift in computing resulted in the development of Multi-Agent System (MAS) technology, which focuses on agent design at the micro-level and social system design at the macro level. MAS seeks to solve complicated issues by utilizing the collaborative and autonomous properties known as agents. Diagnostics, condition monitoring, power system restoration, market simulation, network control, automation logistics, manufacturing, operational research and management science, socio-technical studies, land use and land conversion, industrial engineering, technological innovation, control engineering, and workbox systems are among the applications for which MAS technology is being developed. Furthermore, the technology has progressed to the point where most MASs are being relocated from the lab to the field, allowing the industry to acquire experience with MASs while also evaluating them. MAS has been used extensively in power engineering [11], [12]. A list of some of the applications is presented in Table 5.

Table 5. Fames Seven Applications Domain In MAS

NO	Applications	Domain
1	Office automation/ engineering support	Mail filtering, meeting scheduling, intelligent assistance, training, and performance support
2	Information access	Retrieval, filtering, and integration from multiple sources
3	Network management	Using a network management system, network administration is administering, managing, and operating a data network. Modern network management systems use software and hardware to collect and analyze data regularly and send out configuration changes to increase performance, reliability, and security.
4	Smart grid operation	A smart grid is an energy network that employs digital communications technology to enable the two-way flow of electricity and data and the detection, reaction, and prevention of changes in usage and other issues. Smart grids are self-healing and allow power users to influence how the system operates.
5	Monitoring	Monitoring is the process of gathering, analyzing, and interpreting data to follow a program's progress toward its objectives and to guide management decisions.
6	Power system control	Power system control requires maintaining intended performance and stabilizing the system after a disruption, such as a short circuit and loss of generation or load. Power system controls to keep the power system safe and secure by preventing harmful events.
7	Protection	Protection is any step taken to safeguard anything from damage caused by external factors.

3.2. Application of MAS based on software platforms

Various literatures give several open-source agent platforms for executing any MAS system. With these agent platforms, it becomes much easier to design MAS for challenging systems. Java Agent Development Framework is one of them (JADE, Zeus, VOLTRON) and can summarize various software platforms in MAS, which is shown in Table 6.

Table 6. Summary of various software platforms in MAS

Features	Jade	Zeus	Voltrons
Free and open source	✓	✓	✓
FIPA compliant	✓	✓	☒
Editor	Command-line	GUI	Command-line
Platform	Active, updated	Discontinued	Active, updated
Programming language	Java-based	Java-based	Programming language independent
merit	A stable platform	Developmental ease	Support for hardware drivers
Limitation	New developer challenges	Documentation is lacking.	Limited industry adoption
Appropriate usage	Scalable systems	Rapid prototyping	Building energy management

3.3. Merits and Limitations of MAS

Every technology has advantages and disadvantages, and MAS is no exception. There are certain drawbacks of using MAS and some advantages that have to be considered. In Table 7 below, the benefits and limits are briefly described.

Table 7. Merits and Limitations of MAS

Merits	Limitations
▪ MAS as a method for developing resilient, flexible, and extensible systems ▪ Distributed architecture: The distributed character of the generation feeds into MAS design schemes that rely on local knowledge and decision-making. ▪ MAS provides edibility in various methods, including "plug and play" system changes and diverse types of agents that model heterogeneous sources and loads. ▪ Resilience: MAS can react and adjust to problems fast. Changes in network topology (such as disconnecting a load or generator) will not disrupt both local and global system objectives (such as stability and efficiency).	▪ Emergent behavior: Unpredictable results are possible because agents are independent and scattered. While agents' aims and objectives can be programmed, the effects of run-time interactions are not always predictable. ▪ Portability: Implementing hypothetical MAS ideas and architectures on hardware might be difficult. ▪ Scalability: With today's computing capability, researchers can model larger micro-grids with several agents coordinating actions on a single platform. ▪ Security: As infrastructure shifts from primarily physical to smarter technology, the risk of security and privacy breaches from malevolent external actors and disruptive forces increases.

4. Review Methodology

Our goal is to evaluate and assess sustainable agent and MAS research over the last decade from various angles, (ii) offer a unified conceptual framework for sustainable MAS, (iii) emphasize the significance of reliable MAS, and (iv) design a specialized field named medical picture application, (iv) give a case study of long-term MAS, and (v) identify gaps in the research that need to be filled. It was removed from the review because the study covered a broad and imitable "sustainable" approach. We looked at publications from journals and sources that primarily appeal to industrial and applied sciences. This study aims to examine and extract relevant information from journals to assist academics and practitioners in formulating a response that is targeted to their specific business needs. We began the review by searching SCOPUS for Title, Abstract, and Keyword using the keywords (Agent or MAS) (agent model AND MAS review) and narrowing the results to peer-reviewed publications published in English language journals after 2018. This resulted in a total of 788 articles in various subject areas. Figure 3 shows the search strategy for literature in this review article. Firstly, we seek to carefully describe and consolidate the differential knowledge of current literary studies and provide a complete additional analysis of the problems of the agent and the MAS in image processing applications.

Most articles include "image segmentation in multi-agent systems" and other search phrases. We discovered that the phrase "agent for image processing" is vague, including papers on industrial automation, edge AI, instrumentation, non-process type entities, and self-driving cars. Finally, we focused our search on the application of MAS in image processing, such as compression of images based on MAS, segmentation in medical images, and image revival. It shows that several MAS-based approaches are applied to the image segmentation to produce a successful search with the promising performance achieved using powerful MAS algorithms.

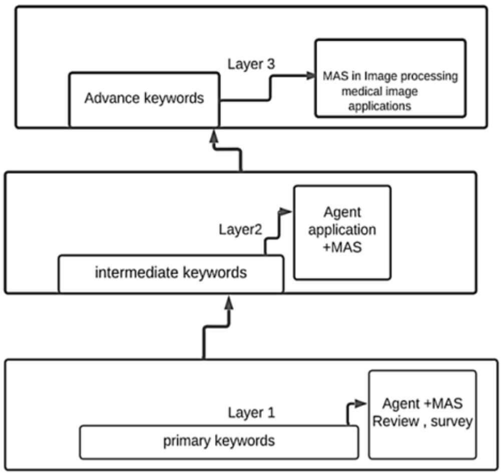

Figure 3. Keywords search techniques

5. Review finding on MAS in medical Image

Recent advances in machine learning, particularly deep learning, have increased the performance of medical picture segmentation algorithms. It yields encouraging outcomes. Nonetheless, additional issues about the learning process have been highlighted, including the requirement for vast amounts of manually segmented data, the time and energy required to train, and the potential of overfitting. Researchers are investigating the possibility of using MAS to circumvent these obstacles.

Numerous multi-agent techniques for medical image segmentation have been suggested. Agents in the first category encapsulate a pre-existing algorithm. Thus, the agents disseminate and enhance traditional segmentation methods. Specific systems employ the preprocessing tools on picture subparts to identify pixels according to a predefined set of classes which can utilize this technique for segmenting MR brain images [13]. In contrast, it is utilizing them to segment CT images [14].

A non-Autoregressive Image Captioning (NAIC) model with a training paradigm: Counterfactuals-critical Multi-Agent Learning [15], (CMAL). CMAL describes NAIC as a multi-agent reinforcement learning system in which places in the goal sequence are considered agents which are learning to maximize a sentence-level reward jointly. To improve captioning performance, this project uses many unlabeled photos.

Bennai et al. developed a method of a multi-agent system, MAS, to segment medical images. MAS permits the simultaneous identification, through many regions, thresholds, or certain features predefined with the students' learning or previous knowledge, of distinct regions without user inputs relating to the image type. MAS uses a population of interacting agents who accomplish two critical tasks: seed separation of voxel and tissue extraction region. After all, regions have been extracted; the agents begin a collaborative process of the merge.

The advantage of this method is that it suggests a distributed adaptation of the well-known simulated rinse algorithm and incorporates the idea of social welfare, in which agents evaluate both individual and societal rationality[16].

3D Image processing is a challenge. They proposed a solution by improving the multi-agent segmentation approach to achieve a growing method combined with contour detection. The agent checks possibilities of knowledge to make the 3D outcomes [17].

The research offers a multi-agent system and FCM-based segmentation procedure for remote sensing. This agent extracts, identifies, and fuses image 204 characteristics and obtains improved segmentation results. The critical agent is implemented based on fumigated clusters that use fluid learning and unsupervised clusters to improve the precision of segmenting results and noise immunity. The study shows promising results because of the multi-agent system in remote imaging segmentation [18].

A technique proposed in [19] to increase the precision of segmentation results and accuracy, the primary design agent for the segmentation work is carried out through the MRF-driven technique. This article shows the perfect result of the multi-agent system for remote sensing picture segmentation.

For advanced image segmentation, the method offers competitive results with machine learning algorithms that are subject to current trends in image processing. To develop a broad approach, our investigations deal with image segmentation problems. This approach defined a relevant methodology leading to relevant results. Research has shown that a well-defined multimedia suitable method can increase the continuity of research in the segmentation of medical images.

There are numerous approaches to compression to lower the size of the image. These methods take advantage of image properties and features to make the coding more condensed. Other algorithms allow restoring the original image after the image is compressed. At this level, we have to notice two kinds of image compression: compression without loss of information (lossless) [20]; in this case, the image restored has to be fully compatible with an original image; compression with information loss (loss); in this second case, the image re-restored is not fully compatible with the original image [21].

The Commission may determine the fair share of information loss based on the scope of the request for the system concerned. For example, many domains do not require a rigorous copy of the original image but only the elements that characterize it. In this case, one uses the second method to precisely do these critical components without deterioration [22].

Several MAS techniques have been adopted to serve the field of image compression; one approach is compression and decoding. Another approach is based on optimization in image compression [23]. NxM pixels are used for each N line and M column when compressing a table image by assigning one agent to each line. The approach is based on the RLE (Run Length Encoding) method. However, instead of storing occurrences of pixels with the same value followed by the pixel values, it uses a labeling table containing all picture pixel values. Therefore, obtaining a compressed image is a list of color labels followed by the number of color events.

Additionally, previous research established that the generalization agent distributes optimization tasks and images in MAS and then gathers optimum and suboptimal solutions. As a final consequence of its generalization criteria, the generalization agent discovers a solution that works effectively on every picture in the training set. Numerous optimizers employ various optimization techniques to determine the optimal filter bank based on separate training images. They optimize using models given by relevant formulators. The optimization technique considers both the overall compression performance of the image and the filter performance [24]

These techniques, however, have a variety of disadvantages, including an excessive number of parameters. Additionally, most existing methods were developed for a particular picture and cannot be simply adapted to another [25]. We discussed these points and left the issue open for further investigation.

Some image recognition systems have concentrated on achieving highly particular aims such as gender and age classification or recognition of a human image's facial expression. However, the workability of these approaches has been primarily evaluated in a controlled environment (several image and image positions are set in front of the camera, and lighting conditions are regulated.) This issue has encouraged many researchers to explore other solutions. The model proposed by Briones et al. depends on usage for implementing the MAS system. This agent-based technology enables the results of the global system to be significantly improved because diverse agents are responsible for performing functions in the system's operations. Every agent uses an alternative approach, and the best solution is obtained for the shared objective pursued by the agents in the system [26].

The retrieval of digital images, such as image repositories, from enormous Internet resources has become an area of great importance. Text-based retrieval is commonly utilized since it is already well-established as a method of picture retrieval. However, it is not practical since the annotating process takes time. There is also a variation in image content interpretation that influences the process of image labeling [27].

For online indexing of images [28]. Since the development of content-based indexing and retrieval systems, intelligent online picture repositories have included an intelligent technique for reindexing photographs to comprehend better the concepts contained within [29], [30].

The relevant techniques and image processing technologies based on MAS introduced in recent years are classified and displayed in Table 8. Different categories have sub-categories inside them, depending on the principal technology employed.

Table 8. Classification of MAS approach in medical Image

MAS approaches	sub-categories
Image segmentation	▪ Preprocessing dataset ▪ MRI dataset ▪ CT dataset ▪ learning
Image Compression	▪ compression and decoding ▪ optimization in image compression
Image annotation	▪ Indexing of image ▪ Text-based retrieval
Image Recognition	▪ Brain Tumor
Image diagnosis	▪ the diagnosis of disease

6. Discussion and Future Research Questions

The fundamental question behind this piece is: "What does MAS play in the processing of medical images today?

To support a detailed answer, we thoroughly and carefully evaluate the literature. This section will further explore the characteristics of the agent and multi-agent systems, and identify the area where the proposed agent or multi-agent system methodology has leaked in the study. The primary purpose of MAS's image processing approaches today is to fulfill the demand for future intelligence work that characterizes agent-based abstractions, i.e., the cognitive skills required of distributed intelligent system components. However, the process of image retrieval can rarely be considered sufficient to meet industrial and real-world demands.

Logic-based MAS technologies are effectively applied among some 36 papers reviewed for the real world which can only be found in the segmentation and multi-agent system, showing that non-trivial real-world applications are available..

Medical Image processing based on MAS was applied for segmenting, compressing, and recognition of visual patterns; nevertheless, it is worth mentioning that only the segmentation of the image of the brain tumors remained active, as shown in our review. Nonetheless, we believe that the number of advanced technologies that could be utilized in real-world domains is higher than those now used because the preceding analysis is purposefully limited to real-world applications. Therefore, it is necessary to rearticulate the study objective with more critical information about research questions to allow for a query based on this (very general and maybe generic) issue.

(Q1) What medical image processing methods based on the agent model or MAS need to be studied more effectively?

(Q2) Which features and to what extent of MAS technologies are influenced by image processing?

(Q3) Which abstractions/issues/functions of MAS, agent modeling, are not covered under the new medical image processing domain? The above questions open the door for further research work.

7. Conclusion

Medical image is promising in the medical research field as a tool for the heterogeneity of methodology, tools, scope, and scale, which seriously impact the general consistency of research outcomes (not only methods) in most domains. However, MAS has also moved to other areas of research: some of the first MAS may be found in the subject of security in software engineering, for example.

Given AI's recent popularity and the potential significance of MAS in modeling complex, intelligent systems, we believe that MAS-based and technology-based agent can be of widespread interest. Therefore, this study proposes image processing based on MAS along these lines.

By using image technology, researchers consider any agent-oriented software architecture, framework, or language with a transparent logic model and capable of true technical redetermination.

The article follows the conventional MAS methods: We recall, filter, analyze, and categorize the papers manually (Google Scholar, IEEE Xplore, Since direct).

The methodological approach and the inclusion, exclusion, and analysis criteria are rigorously defined and detailed to keep the entire procedure's reproductivity tightly focused. Specifically, we consider only work to determine or use MAS technology based on the reasoning described above and for which there can be demonstrated a specific software reformation. The technologies identified via this systematic research are studied and evaluated from two distinct perspectives; MAS and agent, and agent modeling, all in order to determine which element of MAS and image processing is addressed or utilized by each technology.

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