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Research Article

# Multi-Agent System Applications to Fight COVID-19 Pandemic

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## Abstract

A multi-agent system (MAS) uses multiple interacting intelligent agents with the support of the computerized system. During this COVID-19 pandemic, there is a requirement to improve service for patients to fulfill the ongoing challenges. This technology provides a digital service continuously for the patients. An MAS-based platform is helpful for different scenarios during this pandemic. This article discusses significant components, as used for developing an MAS to handle COVID-19 situations. Finally, it discusses various significance applications of an MAS for COVID-19 pandemic patients. The knowledge and data required to solve the COVID-19 pandemic are distributed spatially in different locations, which add constraints, toward proper planning of the treatment of patients to combat this pandemic. Governments accept that their systems cannot stop the widespread transmission of this virus. However, by flattening the curve, the mortality rate can be reduced. MAS consist of autonomous entities, also known as agents, who work collaboratively. By using MAS, lots of real-world data of the emerging situation such as an outbreak can be processed gainfully. It will allow doctors and organizations to create flexible models of potential scenarios.

**Keywords:** COVID-19, health care, multi-agent system applications, multi-agent system components, multi-agent system, pandemic

## Introduction

One of the fundamental problems of health-care sectors and social services is the lack of communication among all the stakeholders involved. A multi-agent system (MAS) is a medium by which active collaboration of information exchange and communication between different information systems that are not related to each other can occur without affecting the security of the assisting agencies involved. It is a computer-based environment that consists of multiple communicating intelligent agents. Different entities or agents work in coordination to find solutions to problems that are not in the domain of the individual capabilities or comprehension of each entity or an agent. Reactivity, proactivity, social skills, decentralization, and autonomy are the properties of MAS. In MAS, agents work without human interference, but they can exchange information with other agents.[1] It is a new and promising area of distributed artificial intelligence (AI) and the mainstream computer science field. Research has recently been successfully carried out for patients to tackle and meet challenges during the COVID-19 pandemic.[2]

The health-care field has already created major advancements by the applications of different technologies such as AI, the Internet of Things, big data, and telemedicine. These provide digital solutions and fulfill major requirements during the COVID-19 pandemic.[3,4] The major benefits of this technology are to minimize the face-to-face interaction between patients and doctors. This virus has time to sustain the different surfaces, and proper precaution is required during these days.[5,6] These days, there is a shortage in the supply of medical equipment and other devices. Three-dimensional printing is now available to print some parts such as masks, gloves, and ventilator parts in lesser time.[7,8]

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## Major Components Used for Developing a Multi-Agent System to Handle Patients during the COVID-19 Situation

Table 1 represents the essential components of an MAS being developed to tackle the COVID-19 pandemic situation, regionally and globally.

## Applications of Multi-Agent System for Patients during the COVID-19 Pandemic

### Decision support system for patients

Decision-making is one of the most critical parameters for patients during this COVID-19 crisis. A decision support system is distributed in nature, which helps the health-care staff to make the appropriate decisions during the treatment of any patient. Monitoring the status of hospitalized patients can be performed autonomously.[10]

### Emergency management of patients

Every day, the number of cases are increasing due to this COVID-19 pandemic. Therefore, it is essential to provide better emergency management to tackle critical patients effectively. Managing emergency patients during this crisis requires real-time practices and efficient resource utilization. The status of the patients in the emergency ward is shown with a real-time system. This feature of MAS makes emergency management very useful during the COVID-19 pandemic.

### Patient scheduling for treatment

Patient scheduling is associated with the optimal assignment of medical facilities to the infected patient.[11] During the COVID-19 pandemic, patients are arriving continuously at the hospital for treatment, so patient scheduling is necessary. The duration of treatments and examinations is stochastic. MAS provide an appropriate solution to such problems by providing properties such as autonomy, reactivity, and proactivity.[12]

### Medical data management of patients

In medical data management of a patient, the MAS focuses on the cognitive process of bringing stored information into consciousness and processing of medical data. During this pandemic, a large number of medical records are made available electronically. In COVID-19, the MAS can be used to collect, filter, and organize this information. By using MAS, agents can access physically distributed information sources to draw out and combine information, which may be used as a foundation for developing a decision support system.

### Planning and resource allocation for patients

In the crisis like the COVID-19 pandemic, proper planning and resource allocation are essential for the treatment of patients. In the health-care process, different entities such as professionals and physical resources should be adequately managed using appropriate planning methodologies. This problem can be sorted out by using an MAS. Hospital is an open multi-agent-based platform for the applications in health care, which are distributed in nature.[13,14]

### Remote care of patients

In the COVID-19 pandemic, remote monitoring is essential to monitor the status of patients remotely. For this application, the MAS consists of the following three elements: several sensors, an analysis of the sensor's signal to identify the difficulties and generation of alarms, and reports for the staff of health-care management. During the coronavirus crisis, old-age people are affected very quickly. The Aingeru system provides incessantly monitoring of old-age people.[15]

### Composite systems for patients

Composite systems are agent-based platforms that are being used in the coordination of activities for patients. MAS perform these activities to provide efficient health care to the infected patients during the COVID-19 pandemic. These systems combine AI techniques and agent architecture under the umbrella of e-health.

### E-medicine for patients

E-medicine is the digitalization of medical processes and services for patients. It may include telehealth, telemedicine, and other healthcare-related activities such as health education, health-care management, and training.[16] During

**Table 1: Components and their handling role for a multi-agent system to handle patients during the COVID-19 pandemic**

| Components | Handling of the COVID-19 pandemic situations |
|---|---|
| Patient terminals | Useful to provide health care to the patient. It is a portable and nonintrusive sensor communication. It is based on the Zigbee or Bluetooth wireless technology. These sensors gain patient-specific information regarding hypertension, body temperature, blood sugar, etc., depending on the patient's current state and history[9] |
| Medical information centers for patient | Medical data centers store EPR and facilitate analytical work and health management of diabetes patients in real time. It includes a knowledge base for the conclusion and reasoning module that works together with a knowledge base in the field of pharmacy, diseases, and EPR systems to help doctors for diabetic patients regarding information and instructions |
| Caregiver terminal | This terminal has two applications, internet portal based and personal digital assistant specific. Due to these applications, it is possible to provide the medical services within or outside the health-care centers for diabetic patients. It will help manage the health protection of patients, undertake diagnoses, and provide prescription medicines to patients and provide treatments, warnings, and suggestions under critical conditions |
| Instantaneous advisor for patient | It integrates the medical knowledge base EPR, to facilitate the timely maintenance of strong patient recommendations for improving the decision-making process, risk analysis, therapy management, and reminders to improve patient care |

EPR: Electronic patient record

this COVID-19 pandemic, telemedicine can provide medical services over a wide area, especially remote rural areas and sharing the current medical information of infected patients and various techniques through telecommunication and information technology.

## Research Implications of the Study

In the health-care sector, a multi-agent-based system has various important applications such as decision support system, emergency management, planning and resource allocation, infected patient scheduling, and remote care. However, there is a difference between prototypes developed in research fields and systems which are being used in actual health-care sectors. Thus, this study provides a primary platform for professionals and researchers so that this gap can be reduced to utilize the actual potential of a multi-agent-based system in fighting against such pandemics. The health-care sector can work in the direction of making the multi-agent-based system a general adoption in all hospitals. There is much work in the front of health-care sector professionals and researchers to be done before agent-based systems are implemented in the medical environment.

### Limitation and future scope of the study

Till date, the use of MAS for patient management and its integration with the routine work of staff is not much effective. There are a smaller number of multi-agent-based systems that are being used in health centers. There is a difference between prototypes developed in research fields and system solutions which are being used in actual health-care sectors. The multi-agent-based system has been developed for a particular organization and has not been deployed in hospitals for patient treatment during the COVID-19 pandemic situation. The most effective method of improving the structure of the MAS in the health-care sector is to increase the application of legacy systems, currently used in hospitals, such as electronic health records. The medical system can be turned into a patient-centric system, which includes a review of patients daily. More opportunities can be created by providing the MAS on mobile devices. A simplified general framework can also be developed as an agent-based medical decision-based support system. Hence, MAS provide a promising approach that can be used to provide patient-centric solutions; there is still much work to be done before agent-based systems become regular in the medical environment.

## Conclusion

A multi-agent-based system provides a software-based platform that enables fighting against this COVID-19 pandemic effectively. This technology is helpful for continuous monitoring of patients during the COVID-19 pandemic for their better treatment. It provides an appropriate alarm and detects any abnormalities of the disease rapidly. This feature of the MAS makes it very useful during the treatment of COVID-19. The major components of this MAS are medical information centers, patient terminals, caregiver terminal, and instantaneous advisor. The medical system can be turned into a patient-centric system that will also focus on the reviews of patients daily. The significant applications of this technology are the decision support system, emergency management, infected patient scheduling for treatment, medical data management, planning and resource allocation, remote care, composite systems, and e-medicine for patients. In future, MAS will provide an effective solution to fight against COVID-19 with better medical services to the patients.

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### Conflicts of interest

There are no conflicts of interest.

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