Survey of Multiagent Systems for Improving Home Health Care Management

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Abstract. Ensuring sustainable care-giving systems with a focus on human needs and desires is a major challenge. An increasing demand in home health care as well as the limited number of professionals in the labor market has led to a call for efficiency. Thus, managing existing resources has gained relevance. The overall goal is high quality care services, while ensuring economic viability. At the same time, there is a need for modern customer-friendly solutions as well as the consideration of employees' preferences. To achieve this, adequate methods are needed that take current and future developments into account. Making use of information and communication technology is obvious. In particular, the use of methods from the field of *artificial intelligence* is an increasing trend in practical applications, such as the use of software agents. The aim of this work is to provide an overview of agent-based approaches for the improvement of the operational management of home health care systems. To this end, we conducted a systematic literature review in which ten relevant approaches were identified. In addition, these publications were analyzed to identify deficiencies and compared to each other.

Keywords: Multiagent Systems · Agent-based Simulation · Home Health Care · Modern Care Logistics · Scheduling · Operational Management.

1 Introduction

Demographic change and urbanization have resulted in an increasing demand for care services. Decreasing birth rates and improved health care cause a higher ratio of elderly people, which potentially become care dependent. Due to globalization and an increasing willingness of younger people to relocate, relatives who could provide care might not be available. Furthermore, it is possible that the employment status of relatives does not allow them to provide intra-familial care services. Hence, it can be assumed that there is an increasing trend in demand for professional care services. In the near future, any decrease in the tendency of this development can not be expected, meaning that ensuring sustainable care-giving systems with focus on human needs and desires is a major challenge.

Instead of receiving care services in specialized care facilities, many care-receivers prefer to stay in their familiar environment. Such services are offered by home health care (HHC) service providers. The caregivers are equipped with cars and render the required care services in the respective patients' homes.

By this means, care dependent persons receive the required assistance while maintaining their current way of living. To cope with an increasing demand in HHC, additional caregivers must be hired by service providers. However, in the labor market, qualified caregivers can be considered to be a limited rare resource. Following this, managing existing human resources in HHC gains in relevance to enable efficient employment. In this regard, the cost-benefit ratio of provided care services must be traded off against ethical aspects of care. The overall goal is to provide high-quality care services, while ensuring economic viability.

At the same time, modern customer-friendly solutions as well as the consideration of employees' preferences are required. Methods from *classic care logistics* focus on the scheduling and routing of caregivers. Yet, these methods do not seem sufficient with regard to *modern care logistics*, where in addition the individual desires of both, caregivers and care recipients, are considered as well as interaction between the participants. This includes the flexible adjustment of individual tasks or schedules for adaptively dealing with a dynamic environment. Moreover, taking real world data into account can be necessary to achieve a proper planning result (e.g., traffic delay data). This also allows for dynamic changes of preferences: On the one hand, caregivers can for instance receive flexible schedules so commuting times can be reduced by taking the company car home. On the other hand, care receivers, for example, are able to alter appointment time windows and demanded care services in the short term. Furthermore, management instructions should not only define or designate the tasks, but also define the scope of action based on individual qualifications, preferences, and other personal attributes of each participant. By this means, individuals are provided with both instructions on what tasks they have to accomplish and instructions regarding flexibility in their execution (e.g., sequence of accomplishment, type and manner of execution, as well as individual adaption of a task).

From an HHC provider's perspective, the management of this situation is challenging. Adequate methods are required that take current and future developments into account. To allow for corresponding management, resulting requirements can be summarized as a need for flexibility in caregivers' operations, efficiency in the use of resources, and economic viability under present and future conditions. Considering these requirements, it is questionable whether and to what extent they are met by current approaches. In case no satisfying methods can be identified, as a first step, the question of shortcomings arises. To close this gap, the goal of this paper is to provide an overview of current approaches for the operational management of modern home health care systems. Moreover, if current approaches show deficiencies, these shortcomings must be analyzed and resulting challenges derived. To this end, a systematic literature review has been conducted in order to gather relevant contributions.

The remainder of the paper is structured as follows: Section 2 presents background information. Section 3 introduces search criteria and the methodology pursued in the literature review. The fourth section gives an overview of the surveyed approaches and in section 5 shortcomings are described. Finally, the conclusion of this article and comments about further work are provided.

2 Background

To increase the efficiency of the operational management processes as well as the managed processes, the need to use information and communication technology is obvious. The application ranges from basic technologies for carrying out daily management tasks to comprehensive support for difficult decisions using special software systems. In particular, the use of methods from the field of *artificial intelligence* (AI) is an increasing trend in practical applications. This area includes the concept of *agents*. An agent can be described as a software entity or a robot (hardware), that is able to perceive its environment and to act upon that autonomously [13]. Hence, it can for instance a part of an automatic workflow or an individual representative of a real-world person. Taking individual stakeholders into account as well as the need for flexibility as described in Section 1, the usage of methods that form the field of *multiagent systems* (MAS) and *agent-based simulation* (ABS) seems promising. They can be used in many different ways, e.g., a distributed software system can be used to support automatic coordination of real-world participants in their operations. In particular, multiagent technology is known for offering flexible solutions and adaptive IT systems [6]. Furthermore, assistance systems with agent-based simulation components are able to provide decision support based on the execution of simulation runs, which try to imitate the behavior of the real system. Evaluating various ideas on a simulation model of the real world can be less expensive and time-consuming. The use of multiple agents as a modeling paradigm to build artificial societies or social systems is a unique way of testing theories for many application domains [9]. Beside that, simulation can also be used to evaluate the functionality of a developed MAS by placing the system in a simulated environment. The following description from Wooldridge is helpful for classifying the terms: "A multiagent system is one that consists of a number of agents, which *interact* with one another, typically by exchanging messages through some computer network infrastructure." [17, p. 5]. Thus, an agent-based simulation can be seen as an MAS as well. In the following, the term MAS is used to describe a distributed software system and distinguish it from a software system which makes use of an agent-based simulation.

The development of both MAS and ABS can be observed in relation to the domain of HHC. The term *home health care* refers to "the provision of healthcare services to people of any age at home or in other noninstitutional settings" [2, p. 9]. To distinguish skilled medical services and nonskilled services (like personal care routines, household maintenance and social services), the latter is described using the term *home care*, while *home health care* includes medical treatments, nursing services, and physical therapies [12]. To support management in both sectors, various research areas are working on innovative methods. For instance, in *operations research*, scientists work on the optimization of daily routing and scheduling for HHC services [3]. To reduce the coverage of the entire range of operational management tasks, the following sections focus on supporting the HHC service provider's resource scheduling. This refers in particular to planning the deployment of employees, i.e. which employee takes on which tasks at which point in time.

3 Review Methodology

As mentioned in the previous section, various approaches exist that apply MAS and ABS in HHC. In order to investigate how and to what extent existing approaches contribute to the operational management of HHC systems, applicable approaches must be identified and analyzed. The conducting of a systematic literature review seems reasonable. For this purpose, search criteria must be defined and applied using a methodologically sound procedure. In this section, both key features for the review and corresponding methodology are presented.

3.1 Literature Search

The identification of relevant approaches was conducted in March 2018 as a systematic literature search. To this end, a *backward snowballing procedure* was chosen: The reference list of a scientific paper is used for identifying new relevant papers to examine and the references from these selected papers are also used in further iterations [16]. First, we generated a literature start set with the help of a web search engine. After that, the references of this start set were used to find further relevant papers, so a second literature set was created. The references of the second set were examined and no further relevant papers could be found. All selected papers were examined in detail and finally ten contributions presented as the result. The age of the identified approaches ranges from 2006 to 2017 (no age limit imposed). Since background-related biases are possible, it should be mentioned that the education and experience of the authors focus on the field of design-oriented information systems research.

At the beginning, a web search engine is chosen for the generation of the literature start set. Despite the risk of grey literature, *Google Scholar* was chosen, because of an absence of knowledge of relevant databases for the considered domain and also because of the fact that the search engine was only used to create the start set. To achieve a small number of iterations in the snowballing procedure, multiple keywords were combined in a search string to generate a suitable literature start set which comprises a high number of papers containing relevant information. The search string used in the search engine is listed below:

("home-care"|"home care"|"home health-care"|"home healthcare"|"home health care"
|"home health nursing"|"caregiver"|"caregiving"|"long-term care"|"long term care")
("multiagent"|"multi-agent"|"agent-based"|"agent based")
("scheduling"|"roster"|"plan")

The search string contains three groups of keywords, separated by the use of brackets. Each group refers to a domain, which should be represented in a search result. To increase the probability that all three domains are addressed in a search result, the groups are concatenated with logical conjunctions. The first group of keywords specifies the domain of HHC. The second group focuses on the use of the concept of a software agent as described in Section 2. The third group specifies the considered operational management in terms of the HHC provider's resource scheduling. The use of quotation marks defines a string-based search.

Due to different writing styles, several alternatives are concatenated with logical disjunctions. Furthermore, disjunctions are used for different keywords which describe the same domain. As a result of the usage of the explicated search string, 16 scientific papers were selected by examining 200 search results (20 result pages). All relevant papers were found in the first one hundred results. Following the snowballing procedure, the references of those 16 papers were evaluated and a second literature set was generated containing two scientific papers. After a detailed review, both were rejected. Further iterations of the snowball procedure were counteracted by finding useful results with the search engine in the first step. Due to the application of a comprehensive search string, several papers within the first literature set have mutual references.

3.2 Key Features

To analyze the suitability of the identified approaches, different perspectives of the scientific process must be considered. Before the respective content is presented in the next section, the categorization and the usage of the review key features are explained. As a first step, the *concept* is examined to determine how and to which purpose the agent-based system is utilized. Further, the practical *implementation* as well as the *evaluation* of the system are investigated. While the implementation focuses on the availability of software and hardware systems, the evaluation makes sure that the developed concept is applicable in the field.

Five key features are related to the concept. Beside a brief description of the *approach*'s main ideas, the target group of users is identified. In this regard, the *outcome* or *product* that is provided to the user is described. Moreover, methodical limitations and focus of the considered approach are characterized by the key features *spatial aspects*, *goals and constraints*, and *agents*. The latter designates the agents, which are identified in the approach. The feature *goals and constraints* comprises the targeted performance measures as well as restrictions of the parameter or solution space. The feature *spatial aspects* determines the consideration of any geographic related entities or factors in the model, such as distance computations, traffic predictions, map data, and regional restrictions.

After taking a conceptual perspective, the provided implementation is analyzed. When implementing a MAS or an ABS, the use of an existing modeling and simulation (*software*) framework is feasible. By this means, common functionalities are provided, which improves the reusability of the implemented concept. Here, a differentiation has to be made between free-to-use and commercial frameworks. This is directly related to the key feature *accessibility*, which describes whether or not the implementation is available for further use in terms of the used licensing model as well as the provision, e.g., in a public repository. Furthermore, the *interactivity* of the implemented approaches can vary. While some approaches do not allow for real-time interaction, others are equipped with interfaces, which enable the interaction with one or multiple users and also between the involved users.

In the evaluation perspective, the implemented concept is practically applied to health care scenarios. In terms of MAS or ABS, the evaluation commonly consists of simulation experiments that are conducted as part of a study. This includes design, execution, and analysis of simulation experiments. The *design of experiments* comprises techniques for the identification of relevant experiments (design points; DP) as well as the systematic limitation of the considered parameter space. For stochastic models, the estimation of the required number of replications (sample size; N) is another important task. In addition, input data is required for the definition of the simulated scenario. The key feature *input data source* distinguishes between synthetic and real-world data, and gives background information like geographical affiliation. Output data that is generated during the execution of the model must be analyzed to draw conclusions about the observed behavior of the system. Based on this, the key feature *output data analysis* describes what means are applied and what efforts are made for assessing statistical significance.

4 Approaches for Improving HHC Management

The goal of this work is to survey existing approaches that make use of ABS or MAS to improve operational HHC management in terms of resource scheduling. As a result of the execution of a literature study, ten relevant approaches for HHC management were identified. In this section, a comprehensive overview on as well as a comparison of these approaches is presented, which allows for the identification of shortcomings (cf. Tables 1 and 2).

To judge whether and to what extent each of the specified key features (cf. Section 3) are satisfied by the approaches, only evidence is used that is directly provided by the scientific publication in which the approach is proposed. Accordingly, in case specific aspects of the system are not discussed in the publication, it is assumed that the approach is not capable of fulfilling the respective key feature. The same applies for ambiguous descriptions or assertions regarding functionalities of the approaches. To avoid misinterpretations, the assessment which is presented in this section is not based on assumptions in terms of interpretations of text passages. Instead, the wording of the authors is adopted for the description of the approaches. As the terminology that is used for describing the surveyed approaches is not unified, ambiguousness and terminological inconsistencies might occur in the following discussion of the contributions.

The framework proposed by **Castelnovo et al.** [1] consists of an ABS of the interactions between different actors that are involved in home care processes. In this regard, the authors make use of the *contract net protocol* to model task distribution between the agents. The goal of the model is to enable patients to stay at home instead of being forced to stay in professional care facilities in case this is not medically necessary. The presented approach is implemented in *Arena* and evaluated in a case study of a *Palliative Home Care Program* from Italy.

Itabashi et al. [5] present a more comprehensible approach using MAS for the negotiation of care schedules. Equipping caregivers and patients with PDA devices enables the dynamic request of care services as well as the real-time confirmation or rejection of resulting care schedules. The approach aims at minimizing the overall costs of service as care schedules can be adjusted to efficiently take current care requests into account. In this negotiation process, individual skills of the caregivers as well as date and time preferences of the patients are taken into account. The authors use *JADE* to implement the approach, yet, only present a synthetic example request to demonstrate its feasibility.

López-Santana et al. [7] make use of a multi-objective mixed integer programming model to enable scheduling and routing of caregivers in HHC. To consider driveways in the routing and to minimize travel times and delays, departure and arrival locations of the caregivers are specified. However, the presented approach is limited to a single geographical area and travel times are assumed to be static, i.e., not influenced by road closures or traffic-related delays. The proposed platform works well for small numbers of patients (less than 15) but requires heuristics for the calculation of larger amounts of patients. Like the previously introduced approach, the implementation is based on *JADE*. To this end, the authors present four scenarios with four different parametrizations of the model to illustrate the variation of waiting times.

Of the analyzed approaches, the system presented by **Marcon et al**. [8] provides the most sophisticated and realistic routing. The combination of a global optimizer with a simulation of individual caregiver decision behavior using MAS allows for the agents' perception of random spatial events such as traffic jams to minimize travel or waiting times. By this means, new requests can also be considered by the system. Constraints that must be considered during the scheduling and routing are unspecified and provided by mixed integer linear programming (MILP) or heuristics. For the implementation, *NetLogo* is used and a comprehensive evaluation is provided. The authors present two case studies which are derived from French HHC providers and for each case study 500 working days are simulated. As the proposed model consists of stochastic components, the authors execute 100 replications of each parametrization.

In the approach presented by **Mohammadi and Enyo** [10], the scheduling and routing problem is solved by a central unit and by applying sweep-coverage mechanisms. To this end, the authors goal is not the minimization of travel times but the reduction of the required number of therapists. To demonstrate the feasibility of the algorithm, the authors use a *MATLAB* implementation to execute two scenarios each consisting of ten different parametrizations. To take stochastic uncertainties into account, each simulation run is replicated 100 times.

In contrast to other approaches which aim at optimizing HHC scheduling, the achitecture proposed by **Mutingi and Mbohwa** [11] makes use of a satisficing heuristic. Here, a schedule that is acceptable for all caregivers is generated based on specific thresholds. To this end, an acceptable schedule is not necessarily optimal. Still, the authors aim at minimizing scheduling costs while maximizing both patient and worker satisfaction. Of all the analyzed approaches, this one consists of the most agent types. Besides the types manager, nurse, and patient, the authors define resource, supervisor, and scheduler agents to accomplish multi-objective decision making.

Stojanova et al. [14] focus on scheduling and do not address the routing problem. The authors illustrate analogies between job shop scheduling in logistics and the scheduling of caregivers and elderly people. In the presented ABS, the individuals from both groups are modeled as individual agents which enables communication between the groups. Unfortunately, the resulting simulation is only presented briefly in the paper with the result that the implemented mechanics remain mostly unclear. *AnyLogic* was used for the implementation of the model, however, experiments or generated results are not presented.

The decision support system proposed by **Widmer and Premm** [15] makes use of an auction-based protocol (double-auctions) to achieve an optimal allocation of caregivers to dementia patients. By this means, they aim at maximizing social welfare by taking the time required for each service, the skills of each caregiver, service priorities, and valuations of the patients into account. The specification and justification of the proposed auction protocol is the main contribution of the paper. In this regard, a software architecture as well as dementia-specific requirements are introduced. Unlike other contributions that use simulation for their evaluation, the authors present a scenario-based evaluation to demonstrate the submission of bids as would take place during an auction. The prototype is developed using only *Java* and no dedicated agent framework.

Xie et al. [18] present an MAS framework that implements an iterative bidding procedure for the negotiation of HHC schedules. The parties that are involved in this negotiation process are just the home health agency and the caregivers, leaving out the patients. As the routing of the caregivers is not the primary goal of the presented system, spatial aspects such as traffic are not considered. The optimization goal which is pursued by this approach is related to the minimization of service costs. To achieve this, time windows, skill sets of caregivers, and preferences of clients are considered. Even though the authors do not present an implementation, they provide experimental results and compare them to the optimal problem solution generated by means of *ILOG*. For this purpose, eight scenarios are defined each of which is replicated ten times.

Two years after their publication in 2015, two of the authors from the previously presented work proposed another scheduling approach for HHC. As the approaches differ considerably, the system presented by **Xie and Wang** [19] is discussed as well. Unlike the previous publication, the authors propose an ABS for generating and evaluating care schedules using a repair algorithm. Moreover, a spatial aspect is added, so a GIS map serves as operative environment in the simulation. For the implementation, the authors used *AnyLogic* and demonstrate the feasibility based on ten repair runs. As no information on the chosen scenario is provided, it must be assumed that the data basis was generated synthetically.

Beside these ten selected approaches, the idea presented by **Fraile Nieto et al.** [4] is worth mentioning. The authors apply an abstract MAS architecture to a home care scenario. This can be conceived as a part of a management solution. Because of a lack of elaboration in the area of resource scheduling, the publication is not part of the table. The authors only mention that it could be possible to use this architecture for scheduling medical staff.

Table 1. Overview of the concepts of the surveyed approaches.

	Approach	User	Outcome/Product	Spatial Aspects	Goals and Constraints	Agents
[1]	agent-based simulation of home care organization model	HHC service provider	framework to control the home care processes at an operational level	-	-	-
[5]	MAS for negotiation of care schedules	HHC service provider	communication system, care schedule	-	G: MIN total cost of service; C: skills, date/time interval	interface, schedule, helper
[7]	multiagent approach using mixed integer programming model	HHC service provider	communication platform, scheduling and routing for caregivers	arrival/departure location, static travel times, multi-depot	G: MIN travel time, MIN delay arrival time; C: skills, locality, priority	patients, organizer, coordinator, caregiver
[8]	global optimizer and ABS of caregiver behavior to solve routing problems	HHC service provider	system for solving scheduling/routing problem in dynamic context	random events (e.g., traffic jams and road accidents)	G: agents' decision rule (e.g., MIN travel or waiting time); C: unspecified	patient, caregiver
[10]	sweep-coverage for efficient monitoring of patients by means of a MAS	HHC service provider	inf. management system, solving of scheduling and routing problem	distance from service providers facility to patients location	G: MIN No. of therapists; C: location of patients and therapists	patient, therapist, hospital
[11]	MAS with satisficing heuristic for staff scheduling	HHC service provider	theoretical framework for staff scheduling and task assignment	-	G: MIN schedule cost, MAX patient/worker satisfaction; C: tasks, preferences	manager, patient, nurse, supervisor, resource, scheduler
[14]	scheduling algorithm and agent-based simulation	HHC service provider	system for generation/analysis schedules	-	G: MIN processing time; C: servicing time	patient, caregiver
[15]	MAS for negotiation of caregiving resources using double auctions	HHC service provider	Agent-based decision support system for allocation of resources	-	G: MAX social welfare; C: time/priority for service, skills, valuation of patient	patient, caregiver, auctioneer
[18]	MAS for negotiation between home health agency and practitioners	home health agency	iterative bidding framework as a decentralized decision making tool	-	G: MIN service costs; C: time, skill set, preferences	-
[19]	ABS for evaluation of schedules generated by repair algorithm	HHC service provider	system for generating and evaluating schedules	GIS map as operative environment in simulation	G: MIN service costs; C: practitioners availability/eligibility, visit time	practitioner, healthcare agency

Table 2. Overview of implementation, experimentation, and domain of the surveyed approaches.

	Software	Interactivity	Design of Experiment	Input Data Source	Output Data Analysis	Domain
[1]	*Arena*	-	sensitivity analysis	1 case study (palliative home care provider in Milan, Italy)	average values of a performance measure (waiting time)	Palliative Home Care
[5]	*JADE*	caregivers and patients reject/accept proposed schedules	-	1 example of single request (synthetic data)	-	HHC
[7]	*JADE*	allows for new requests during run time	DP = 16, N = 1, deterministic/stochastic model (unclear)	4 scenarios (synthetic data)	average values of a performance measure	HHC
[8]	*NetLogo*	real-time request of availability of patients	2 simulations of 500 working days, stochastic model, N = 100 for each decision rule	2 case studies (synthetic data, inspired from classical types of French HHC providers)	statistical significance (confidence interval), evaluation of efficiency, pertinence, scalability, robustness, and implementability	HHC
[10]	*MATLAB*	assumption: appointments can be made by patients	DP = 20, N = 100, stochastic model	2 scenarios (synthetic data)	average values of a performance measure	HHC
[11]	-	update of preferences and management goals	-	-	-	HHC
[14]	*AnyLogic*	-	-	-	-	HHC
[15]	*JDK*	caregivers and patients submit bids to an auctioneer	-	1 scenario (unknown data source)	-	Dementia (Home) Care
[18]	-	-	comparison to optimal solution of 8 model configurations (DP = 8), N = 10, stochastic model	8 scenarios (synthetic data at realistic scale)	average values of a performance measure (bidding solution payment)	HHC
[19]	*AnyLogic*	-	10 repair runs	assumption: synthetic data	average value of a performance measure (costs)	HHC

5 Shortcomings of the Surveyed Approaches

The previous section analyzed the identified contributions with respect to the defined key features. Considering Tables 1 and 2, it seems that none of the surveyed approaches is satisfactory for supporting operational management in modern care logistics. In consideration of key features that can be used for assessing the contributions of the surveyed publications, shortcomings can be identified. In this regard, those key feature that do not allow for drawing conclusions about the suitability are not further considered, such as *approach* and *user*.

Shortcomings in the approaches' concepts are mostly related to *outcome*, *spatial aspects*, and *goals*. It can be observed that an *outcome* for the HHC management that is "ready to use" does not exist. Beside theoretical contributions (like frameworks), the publications provide outcomes on a prototype level. Further, *spatial aspects*, such as traffic times or map data, are not sufficiently considered. Instead, for instance static travel times are used or travel times are not regarded at all. While specific optimization goals are pursued in nine out of ten publications, only one system allows for the interchangeability of goals. In the one remaining, a static context is given. Shortcomings in the implementation of the approaches are observed in terms of used *software* and its *accessibility*. Through the use of commercial frameworks, a third-party is included which claims license fees for use. Consequently, a monetary dependency results. Further, a dependency arises in software maintenance and durability. Overall, the applicability of the implementation is strongly limited. Regarding the *accessibility* of the implementations, none of the authors referred to online repositories or websites for downloading the proposed implementations. In the evaluation of the surveyed approaches, shortcomings arise in all defined key features. First, relevant parts of the parameter space must be identified and systematically investigated. Unfortunately, the *design of experiment* in the publications is mostly on a non-professional level. Second, *input data source* in terms of suitable real-world data is not provided sufficiently. Either synthetic data or a brief case study is given. Third, to ensure statistical reliability and the significance of the evaluation results, it is recommended to apply means of *output data analysis*. The greater part of the surveyed approaches uses information about considered performance measures in terms of statistical measurements of central tendencies.

6 Conclusion and Further Work

This article provides an overview of current agent-based approaches for the improvement of the operational management of home health care systems. Therefore, we conducted a systematic literature review in which ten relevant approaches using multiagent technology or agent-based simulation were identified. Further, the identified publications were analyzed and shortcomings were detected. The main criticisms centered on end user provision of the implementation and the evaluation process of the developed concept. Hence, for the practical application, no suitable approach was found. As the demand for management support persists, the development of AI-based assistance systems faces a challenge to assist modern care logistics. However, in order to potentially use the ideas the identified approaches in this work are based on, more detailed information about the individual approaches is required. To provide an objective assessment of the fulfillment of the stated requirements, it is necessary to reimplement these approaches or implement approaches from theoretical contributions. Nevertheless, the result of the literature survey presented here provides a comprehensive overview of current agent-based approaches for improving home health care.

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