

Problem Introduction Form

AI for Social Good Workshop

Deadline: March 15, 2019

Important notes:

- The questions below are typically associated with the construction of good project proposals, but proposals are not expected to answer all the questions. Mentors interested in your project will help you clarify your ideas following the pre-selection process. If a question is not applicable to your project, write in N/A.
- Do not exceed the word limit per question. The completed form must not exceed five pages, including questions. You can optionally add any number of citation pages at the end.
- As the review process is double blind, please do not include identifying information in your proposal.

- **Topics:** Which of the following categories does your problem belong to?

- Education
- Protecting democracy
- Urban planning
- Assistive technology for people with disabilities
- ***Health**
- Agriculture
- Environmental sustainability
- Social welfare and justice
- Sustainable development
- Other

- **Problem:** What problem do you want to investigate and why? If known, what are the root causes of the given problem? What are some existing solutions? (max 200 words)

According to the World Health Organization [1], 1 in 5 people in the world will be aged 60 and older by the year 2050, outnumbering children younger than 5 years. As people age, they are more exposed to chronic diseases: according to a study in 2012, 88% of seniors above 65 years in the U.S. have at least one chronic condition and 25% have 4 or more conditions [2], leading to an increase of hospitalization costs for both patients and governments. In addition, seniors prefer receiving health care in their homes. Thus, Home Health Care (HHC) became a potential answer to these issues in many countries [3] by providing health care in a friendly environment and reducing costs [4]. Nevertheless, for this service to be efficient, HHC systems should allocate their resources in a way that satisfies crucial constraints including, but not restricted to: temporal constraints, allocating competent caregivers with regard to patients' profiles, respecting the patient's preferences such as the identity of the caregiver and increasing the probability of continuous care (one caregiver per patient). Our problem is different from a *traditional* resources allocation problem since the degree of constraints satisfaction is **crucial** to the quality of the service.

- **Proposal:** Describe your proposed solution. How does it address the shortcomings of current approaches? (max 200 words)

We propose developing a novel framework based on reinforcement learning and the attention mechanism to improve the results of previous works targeting the planning component in Home Health Care alongside with the domain constraints mentioned before.

To the best of our knowledge, most of the work already done tackled a subset of possible constraints in small instances without taking into consideration different aspects of a real-world problem. Also, temporal and assignment constraints gained much attention neglecting important real-world aspects such as patients' preferences and dislikes, and synchronization constraints [5]. We aim at providing a general framework that will extend existing techniques with more admissible constraints alongside with alleviating size limitations. Recent papers showed how Reinforcement Learning can be a compelling choice to learn a constrained policy [6]. It provides a flexible approach when combined with neural networks in dealing with this kind of problems while making guarantees about constraints satisfaction, along-side with the dynamic aspect and its robustness to stochasticity we face in concrete situations. The Vehicle Routing Problem is still an essential component in the proposed work to solve the routing part. However, we consider the results from [7], [8] and [9] to address it from a neural perspective.

- **Impact:** What is the expected social impact in the short, medium, and long-term of the solution to the problem? (max 150 words)

Previous works put the main focus on reducing costs. Our method focuses on maximizing the satisfaction of patients' needs which will lead to an effective real-world social impact:

- In the short-term: we will maximize the allocation of resources and address the needs of a maximum number of patients.
- In the medium-term: first, we will try to ensure a continuous care, which consists on assigning the same medical staff to a given patient. Second, we will allocate medical staff with the required qualifications for the patient’s specific health issues and dependence level. Finally, we will try to meet the patients’ preferences, such as the identity of medical staff, which will maximize their general well-being.
- In the long-term: by allocating competent medical staff to patients and ensuring a continuous care, we will reduce the probability of *unplanned hospital admissions* that comes with heavy consequences on all stakeholders [10].

- **Evaluation:** How would you quantify success? Are there smaller-scale environments in which you can test your proposal? How might a larger-scale deployment fail to reflect the initial experiments? (max 150 words)

We will evaluate our method based on different KPIs that measure the satisfaction of patients as the number of patients that receive home care when needed, the number of caregivers for the same patient, the correspondence level between medical staff qualifications and the patient’s needs, health care costs and the frequency of unplanned hospital admissions.

First, we will use existing data to validate our mathematical solution. Second, a possible small-scale real-world environment would be a Local Community Service Center (CLSC) in Québec, Canada (as already done by [11]). This environment might fail to reflect the efficiency of our solution, since resources might be limited as well as the needs of patients. However, a larger-scale deployment will provide a more realistic environment and a larger feasible domain of solutions.

- **Risks:** Could your solution lead to any unintended harmful consequences or risks? Describe them. How could the resulting system be abused? Are there vulnerable populations that might be put at risk? What checks could you introduce to prevent these potential bad actors? (max 150 words)

In this specific problem, the targeted population is vulnerable and sensitive to the decisions that we make. Obvious risks include inadequate health issue assessment, failure to provide well-trained medical staff and delay in receiving more adequate treatment in the hospital. However, we are aware that these constraints are crucial to avoid risks, this is why we put the constraints’ satisfaction in the heart of our method.

The resulting system that we propose could be abused if a caregiver benefits from the fact that they are the only one as a staff member who deals with a given patient and mistreats them in any given way. Nevertheless, we intend to solve this issue by asking patients to give us a continuous feedback about the service.

- **Data:** Describe the dataset(s) available for your project (i.e. amount of data, measurements granularity, data collection frequency, way of accessing the data). Who is responsible for data collection? Are there privacy concerns, and what is the license? (N.B.: In the absence of privacy concerns, we encourage data that can be shared publicly). How have these datasets been used previously? (max 200 words)

It is important to mention that the majority of studies done before have used generated data in their experiments and don't consider any real use cases for their work. Still, we are not following the same path. At first, we will be using a public dataset we found online through the Kaggle platform to address a simplified version of the problem. Next, we intend to collaborate with a Local Health Care Provider [11] who made similar datasets available for previous works.

The dataset contains a wide range of features to treat and formulate our problem. A set of visit records of Home Care Services over two years is given. It was collected from a Home Medical Services Company in the metropolitan area of Barcelona, Spain. This dataset contains 40000 rows (visits) and 15 columns, in which we can find information about the patient (age, location) and his medical status (Pathology, Number of home assistance) and also about the visit (date, time of delay, the visit status).

The dataset was first set for a Kaggle challenge to predict the level of sanitary actions in geographical areas based on environmental agents and its effect on "Fragile" people [12].

- **Labels:** Would your data require any additional annotation before it could be incorporated into your solution? If so, how do you plan on obtaining these labels? Are there different approaches to annotation, and how do they compare in terms of level of detail and ease of preparation? (max 150 words)

Once we establish a set of constraints that are sufficient to model a real use case, we will need to collect features in order to cover these constraints. here we present some potential ones: the qualification of medical staff that should match the needs of patients, and thus we need basic information on medical records of patients enough to distinguish between different conditions. Another interesting constraint is to identify common temporal patterns among patients for instance, conditions with the need of regular visits within the same time slot. This kind of constraints supposes that the needs of patients have already been categorized as punctual visits or regular visits. Also we will be in need of some feedback mechanism to measure patients' satisfaction that can be in the form of a weekly or a monthly evaluation form patients are asked to fill-in.

- **Social System:** Describe your team's skills and backgrounds. What are other resources (i.e. stakeholders, scientists, and funders) would you like to add to your team? (max 150 words)

Our team is composed of three graduate students with solid knowledge and rich experience in machine learning, optimization and supply chain management and two professors, one with an excellent problem solving skills in machine learning and optimization, the other is a health science professional.

Being in a permanent contact with the health science professional can guide us through modeling and defining sophisticated constraints related to our problem and help us gain a better understanding of how home health care works thus showing us what needs to be prioritized.

- **Technical System:** If applicable, please share any technical elements of your proposed solution that have already been explored. What would your baseline system look like, how well do you imagine it will work, and what extensions have you imagined? (max 150 words)

From a technical point of view, the planning of Home Health Care can be seen as a resource allocation problem that can be modeled as a variant of the Vehicle Routing Problem (VRP). This latter have already been addressed using the combination of Reinforcement Learning with the attention mechanism. However, our problem requires taking into account specific **crucial** constraints, which was not tackled in previous works. More importantly, none of these works addressed the home health care problem, which has its own **crucial** constraints to satisfy. We imagine our novel framework to be able to answer the specific structure of the health care problem. We will train our model using the data mentioned above then deploy it as a mobile system, allowing patients to interface with their health care providers instantly with no delays. Caregivers will have access as well to their planned visits in real time.

References

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