A Paradigm Shift towards Crowd-based Healthcare System

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Abstract

Nowadays, it is really difficult to visit any hospitals and consult doctors due to the expeditious rise of COVID patients and in most of the cases it is becoming very difficult to receive the treatment from doctors or nurses. Even in real-life, it can be noticed that admission to any hospital, especially patients with different diseases except COVID is also becoming difficult. Normally, the adults can perceive their health problem by themselves directly and can take the decision. Again, pediatric problems are an emerging issue for new mothers, as it becomes very difficult to perceive the actual problem of their baby and they diagnose it in a passive way. It is already observed that crowdsourcing can solve a complex problem in a very efficient way, therefore, the problems of patients can be outsourced to the crowd to obtain the feedback. Although a spectrum of research has been accomplished utilizing the power of the crowd for chronic diseases, limited work is performed for proper consensus to aggregate the unstructured noisy crowd opinions for any kind of diseases. In this work, we aim to build a generalized crowd-based healthcare system, where in addition to patients, doctors, nurses, general people can act as a vital role. Furthermore, the proper methodologies are developed to understand the population bias, spamming behavior, various opinion biases and wrong judgment provided by them to ensure the quality.

Introduction and Motivation

During this pandemic time, there is already a paradigm shift from traditional healthcare system to virtual healthcare system and employing crowd (Karger, Oh, and Shah. 2011) can be a promising and alternative solution. In the recent past, it can be noticed crowdsourcing can be leveraged as a great tool to solve various real life problems in a limited time and cost efficient manner (Whitehill et al. 2009; Hovy et al. 2013). In healthcare, past research demonstrates that in clinical data designing a trial protocol is not easy, rather it becomes difficult because it is accepted only from a small team and it is merely from 10 reviewers (Carlson 2014). Even it can be seen that the number of patients who review the protocol in a detailed manner is very small and sometimes it appears to be zero. Therefore, crowdsourcing methodologies can be used to accelerate the process.

To mitigate this, already various crowdsourcing-based platforms like PatientsLikeMe (PLM) (Brubaker, Lustig, and Hayes 2009; Wicks et al. 2018) have been developed with an aim to build a network so that people/patients suffering in the diseases can exchange their information and obtain effective feedback from the network. In the same way, during the post-COVID situation, it is a challenging problem to receive treatment at a very early stage whenever any disease is identified. In addition to devising interesting clinical protocols, it can be an alternative solution if, additionally, the traditional physical healthcare system can be transformed to a digital healthcare system. In this process, crowdsourcing can be an alternative and effective tool to construct a large-scale network consisting of patients, doctors, nurses and several other people. Although PLM has been introduced to take care of patients using the power of human intelligence, in that network most of the members are patients concerning condition-specific chronic diseases. Besides it, a limited research has been performed studying various judgment analysis techniques (Chatterjee, Mukhopadhyay, and Bhattacharyya 2020) to mitigate the problems of disseminating wrong information and aggregating multiple noisy feedback while the diseases are not necessarily chronic.

In this large network, patients can upload their problems/ test reports and solicit opinions from the crowd. Here, doctors, nurses, patients and non-patients along with general people can be the members. In this proposed system, basically the patients can receive the alternative solutions as well as multiple feedback promptly from the similar case history and of other patients along with the personalized doctors. Moreover, a number of proper aggregation methods to derive a set of final suggestions is developed to recommend a better solution to the patient. Additionally, an AI based solution is developed that can detect the propagation of wrong messages/texts/images in the network to combat the malicious activities in the network. Furthermore, to realize the reason of a disease due to presence of the comorbid factors, much focus is given on designing feedback aggregation techniques based on diverse expertise of doctors. This type of virtual healthcare system is highly coveted in the countries where the population is large and the resources are limited.

Moreover, limited study is performed to make a reliable system on how to alleviate the propagation of wrong messages. Especially in this work, we are proposing a crowd-based model to serve the whole community for proper decision making including doctor consultation, long-term pa-

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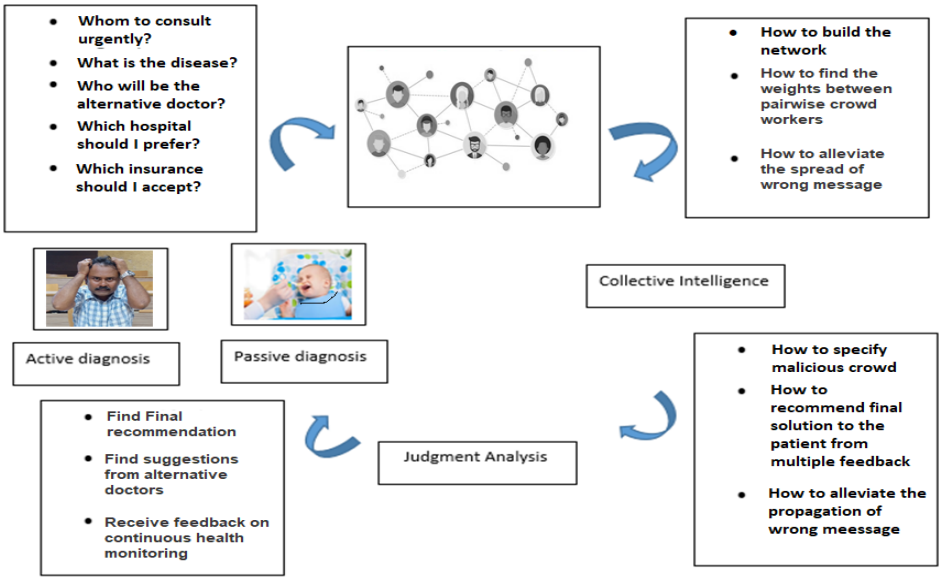

Figure 1: A snapshot of the proposed crowd-based virtual healthcare system

tient monitoring, child care support, choosing appropriate hospital, etc. Simultaneously, we are not only relying upon the feedback of the crowd, rather different machine learning techniques are to be used in order to validate whether the uploaded opinions/posts/images are correct or not. The overview of the whole system is demonstrated in Fig. 1.

Problem Formulation

This problem can be considered in two folds. Firstly, the whole network can be considered as an undirected weighted graph $G = (V, E, W)$, where V denotes the set of nodes that can be the individual crowd. The set of edges between any two nodes are denoted by E and the W denotes the set of weights. In this project basically the nodes comprises doctors, patients, nurses or any general person. Now, the objective is to create a reliable network in order to obtain the most constructive support from the crowd and to recommend the proper guidelines for better decision making.

Secondly, suppose there are m number of patients and those are termed as $\{p_1, p_2, \ldots, p_i\}$ and they obtain the responses from the r number of the crowd. Suppose for the i^{th} patient if he/she obtains the crowd opinions from the k number of crowd from the network, the challenge is how to aggregate the decision of k feedback. Note that, among this k crowd, there are patients and some general persons who can pretend themselves as patients of a particular disease in order to provide wrong information and make the system vulnerable. Hence, the objective is how to aggregate multiple decisions obtained from the noisy judgment.

Proposed Approach

This proposed method comprises three different steps and those are described here.

- **Construction of the appropriate network:** The first methodology is to derive a reliable crowd-based network which comprises doctors, patients, nurses and general people. In this network people are basically the nodes, whereas the edges denote the connection among them. Hence, this network can be treated as a weighted graph and therefore appropriate weights are very necessary to consider the closeness among two people. So based on the professions, past history of medical issues, etc, the network is built. In this regard, different complex network properties like scale-free network, degree distribution, betweenness centrality, preferential attachment need to be observed and various information theoretic based network construction methods are developed (Varela et al. 2015).

- **Reduction of malicious crowd worker:** In this crowd-based network, there are several challenges due to the possibilities of malicious crowd workers. Moreover, when a patient posts any problem in this network and receives multiple feedback from the crowd (may be doctors, similar patients, etc.) then accurate methodology is required to aggregate the multiple feedback. Therefore, different mechanisms considering bias, reliability and accuracy of the crowd workers are considered and various efficient methods are developed.

- **Final recommendation of actual treatment to the patient:** The final opinions are recommended based on a cascading mechanism. Initially, the most preference is given to the doctors having the same specialization. Thereafter, the doctor having relatively similar specialization is taken into account. After doctors, patients' feedback is considered and the priority is given to the patients having similar diseases with the same demographic/age information. Finally, to alleviate the spread of wrong messages the proper aggregation methods for unstructured data and automatic AI-based solutions are developed.

References

Brubaker, J.; Lustig, C.; and Hayes, G. 2009. PatientsLikeMe: Empowerment and Representation in a Patient-Centered Social Network. *Semantic Scholar* .

Carlson, R. 2014. Oncology Times. https://www.opensourcepharma.net/uploads/3/1/7/8/31787557/crowdsourcing_clinical_trial_protocols_april_2014.pdf.

Chatterjee, S.; Mukhopadhyay, A.; and Bhattacharyya, M. 2020. A Review of Judgment Analysis Algorithms for Crowdsourced Opinions. *IEEE Transactions on Knowledge and Data Engineering* 32(7): 1234–1248. doi:10.1109/TKDE.2019.2904064.

Hovy, D.; Kirkpatrick, T. B.; Vaswani, A.; and Hovy, E. 2013. Learning Whom to Trust with MACE. In *Proceedings of the NAACL-HLT*, 1120–1130. Atlanta, Georgia.

Karger, D. R.; Oh, S.; and Shah., D. 2011. Iterative learning for reliable crowdsourcing systems. In *Proceedings of Advances in Neural Information Processing Systems*, 1953–1961. Granada, Spain.

Varela, L. M.; Rotundo, G.; Ausloos, M.; and Carrete, J. 2015. Complexity and Geographical Economics. *Complex Network Analysis in Socioeconomic Models* 19(7): 209–245.

Whitehill, J.; Ruvolo, P.; Wu, T.; Bergsma, J.; and Movellan, J. 2009. Whose vote should be count more: Optimal integration of labels from labelers of unknown expertise. In *Proceedings of the Advances in Neural Information Processing Systems*, 2035–2043.

Wicks, P.; Thorley, E. M.; Semasek, K.; Corren, C.; and Emmas, C. 2018. Scaling PatientsLikeMe via a "Generalized Platform" for Members with Chronic Illness: Web-Based Survey Study of Benefits Arising. *Journal of medical Internet research* 20(5).