Research Article

Rural Healthcare Using Crowdsourcing

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Abstract: There are many motivating key factors that aspire to have a Universal Health Care in the country. Recent studies have shown that the accessibility and availability (Fewer medical practitioners) of health resources are sparse at the time of crisis. These are still the major challenges that are to be achieved in any health care system. In the work proposed, the digital images of biological specimens are transmitted to an e-Health Care (e-HC) module. The digital images are then made accessible by means of crowdsourcing, for specialists to present their accord on specimen that was crowdsourced. The suggestions of experts are then maneuvered based on their qualifications, and their experience in contributing to the society of crowdsourcing. Based on the nature of the specimen, the various opinions collected are then measured by an e-HC module which eventually presents the compiled suggestions to the technicians in the crowd in an e-HC setup.

Asian Journal of Engineering and Technology Innovation
Volume 4, Issue 7
Published on: 7/05/2016

Cite this article as: Syeda Sadia Tabassum, Sathish G C, Akram Pasha. Rural Healthcare Using Crowdsourcing. Asian Journal of Engineering and Technology Innovation, Vol 4(7): 49-57, 2016.

INTRODUCTION

The fact that the health education has improved in urban areas of any province of any country of the world results in substantial anticipation of life in urban areas compared to their rural counterparts [1]. The studies have shown that the healthcare needs of people living in rural places are different from those in urban, and rural places are inherently suffering from inadequate access to healthcare facilities as very few people of working age (20–50 years of age) are found in such rural places.

There are many motivating key factors that aspire to have a Universal Health Care in the country. Recent studies have shown that the accessibility and availability (Fewer medical practitioners) of health resources are sparse at the time of crisis. These are still the major challenges that are to be achieved in any health care system. However, healthcare systems have shown significant growth across the globe from the past four decades. Hence, tremendous efforts are being made to establish the Universal Health Care that addresses these major issues. Subsequently, every country on the globe is looking forward to have a health information system that not only rapidly attend to the people seeking for health support, but also to partially address the problem in the delivery of healthcare resources to every individual in the country irrespective of his dwelling.

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RURAL HEALTH CARE CENTRE

It is the destination place in rural area lacking medical facilities in any country, which working in lieu or verbatim to the standard programs of healthcare in urban regions in the country. that has a separate reimbursement structure from the standard medical office under some Medicare programs.

These programs are to be established to address an inadequate supply of physicians serving Medicare beneficiaries and recipients in rural areas and to increase the utilization of non-physician practitioners [8]. To encourage the development of RHCs serving rural, under-served communities, Medicare needs to reimburse the RHCs based on their reasonable and allowable costs. This model differs from most medical providers, where in the payment is done based on a prospective payment system (PPS) under Medicare to lower overall costs.

Further, any RHC needs to have the following characteristics [7]: at the time of its establishment,

1. defined as non-urban area by the some authorized Bureau/ Body of the country
2. defined as medically under-served by one of the following characteristics:
3. Primary Care Geographic Health Professional Shortage Area (HPSA)
4. Medically Underserved Area under
5. Governor-designated and Secretary-certified shortage area.

The fact that the Internet has grown rapidly from its infancy, it certainly offers possibilities to its users by linking people, gathering information, and delivering services all over the world. Eventually, the Internet forms a solid base for any social network and a so called “Crowd” in particular. Hence, such

tasks that are pertinent to health care can be accomplished by unleashing the caliber of the crowd. In other words, crowdsourcing is one of the recent advancements in the web, contributing the information, ideas, services, and funding that are shared amongst the people across the world. The crowdsourcing becomes both a platform and a bridge, to fill the gap between the donors, those willing to help and the poor, those willing to seek help respectively. As a result, a better platform is set to receive proper health care in the form of Universal Health Care.

CROWDSOURCING

Crowdsourcing is one of the major sources of exploiting the knowledge into reasonable and resourceful action that helps the people in the societies that are inaccessible to full-fledged health-care systems as against the urban dwellers. Basically, it is a method of outsourcing the providers with certain tasks. It acts as a means of exposing the need or a query of a person to the general public or stake holders or to a larger spectrum of people to receive ideas, solutions and/or feedback for their queries, problems and/or action respectively [3]. It is not only acts as a platform that acts as an interface or a bridge between the stakeholders or providers, and the crowdsourcer, but it also serves as an information system that facilitates the interaction between the two irrespective of the dependency of being online.

The 4 Pillars of Crowdsourcing

Crowd: It includes the people who participate in the activity of the crowdsourcer. Recent studies on crowdsourcing have revealed that the participants of the crowd in a crowdsourcing activity bear unique characteristics. Few of these are briefly mentioned below.

Diversity: In crowdsourcing, diversity refers to the process of selecting potential individuals to accomplish a task within the crowd. It is further divided into 4 subcategories based on the some of the attributes of an individual viz Spatial, Gender, Age and Expertise diversity.

Anonymity: In crowdsourcing, it has one or two of these meanings, when the crowd is participating in a task that is unaware of the crowdsourcer, and when the crowd is participating in a task that is unaware about other members of the crowd.

Largeness: In crowdsourcing, largeness occurs when the crowd participating in a crowdsourcing activity is adequate to accomplish the crowdsourcing task.

Randomness: This feature proposes to select individuals in the crowd irrespectivive of their origin, caste, creed and linguistics.

Suitability: The settings such as the ambience, venture, and circumstance are collectively referred to indicate the suitability of crowd to accomplish the crowdsourcing activity.

In this work, the crowd includes the Patients, Technicians, Microbiologists, Pathologists, and other experts in the field of medical.

Crowdsourcer

The crowdsourcer is the one who wishes to accomplish the crowdsourcing task in the crowd. A crowdsourcer can be either an individual, or an institution, or a charity organization, seeking the accomplishment of the crowdsourcing task through the potential of the crowd. The recent studies on crowdsourcing have revealed few of the distinct features of the crowdsourcer as mentioned below.

1. Incentives Provision: It stimulates an individual to spontaneously work harder and act accordingly and take action to solve the crowdsourcing task. Thus, it is a kind of spur or support in the nomenclature of a crowd. However, a crowdsourcer may provide incentives as a kind of meandering motivation for the crowd having several categories of Incentives. It could be a financial incentive to name one amongst many prominent incentives in today's crowdsourcing market.

2. Open Call: It is setting up of stage that is open to anyone who is willing to participate in the crowdsourcing task, the result of which makes a crowdsourcing activity to be accessible to the general public rather than only to a bunch of public. Thus, an open call provides the platform for each one of the participant.

3. Ethicality Provision: It is pertaining to or dealing with morals or the principles of moralilty, or pertaining to right and wrong in conduct of a given profession or a group.

4. Privacy Provision: In crowdsourcing, privacy refers to keeping the crowd's personal and private information unrevealed to any of the participants, or other organizations or other entities related to his/her private life or personal affair. It also ensures that answers revealed by the participating crowd and crowdsourcing activities are preserved undisclosed.

In this work, the Crowdsourcer is the system that we have developed that incorporates handling the incoming reports from Technicians from Rural Areas, sending them to the experts in the crowd and / or resending to different experts during unsatisfied/unaccounted replies, and then integrating their responses based on the formulation of the solution to the problems/diseases the patients might be having if any. Subsequently, replying the suggestions / insights about the inputs received to the concerned sources such as Technicians Crowd.

Crowdsourcing Task

It is an activity which is outsourced by the crowdsourcer and needs to be accomplished by the crowd which can exist in various forms such as a information gathering issue, a fundraising scheme, a problem, or an innovation model. In a nut shell, it is essential to have the expertise, experience, ideas, knowledge, skills, technologies, or money of the crowd, in any crowdsourcing task. Recent studies have shown several characteristics that are required to be pertaining to a crowdsourcing task. Few of these characteristics are as mentioned below.

1. Traditional Operation: The manner the crowdsourced task would have been accomplished in an organization if it were not crowdsourced is what is called as Traditional operation.

2. Modularity: This is accomplished by segregating a crowdsourcing task into several modules of standardized size which can then be integrated together in a variety of ways. It can be an atomic task or compound task that is further divided into sub tasks to be accomplished by the crowd.

3. Complexity: A crowdsourced task may be either a straightforward task, or too complex. Complexity can be distinguished from modularity as some crowdsourced tasks may be complex, but they may be atomic tasks and are not further divided into micro tasks.

4. Solvability: It is the ability of a crowdsourcing task to be solved. Crowdsourcing task is merely a non-computable task which is quite obvious for humans to be solved using any brute force approach, but too complex for computers to solve.

5. Automation: A crowdsourced task is either challenging to compute or too pricey to automate, thus creating substantial challenges to be attained in crowdsourcing. It is worth to note how automation characteristic is distinguished from complexity/solvability of the task. Therefore, the task that is too difficult for computers is eventually too difficult to automate.

Towards identification of biological specimens originated from rural areas, many existing technologies have been proposed that present a solution to the intractable problem of the unmet demand. However, the acquisition and transmission of biological specimens, revealed through low-cost microscopy, to a server would be viewed and analyzed by autonomous members of a crowdsource community, that are either subjected to a system of quality control, or the populations that do not have access to medical diagnostic facilities to perform medical analyses. Therefore, the task of identification of biological specimens by the experts in the field of Medical play the role of a Crowdsourcing task, where in the inputs are typically in the form of digital images that are prepared by the Technicians in the Crowd.

Crowdsourcing Platform

It is a medium wherein the whole activity operates. However, the crowdsourcing platform is generally a website, or an online spot, while there are many examples of real (offline or in-person) crowdsourcing platforms in many studies performed in the literature [4]. Currently, no crowdsourcing platform exists yet that accepts both monetary and in-kind donations, and that makes use of mobile cash as means of donating. In addition, no online platform in the country focuses on health alone. However, the latest reviews found in the literature shows that a crowdsourcing platform normally has four distinct features.

Crowd-related interactions: Among many interactions, some of the key interactions between the crowd and the crowdsourcing platform are enumerated as several schema as shown below:

- Enrolment Schema
- Authorization and authentication schemas
- Declaration Schema
- Allotment Schema
- Help Schema to guide the crowd
- Submission Schema for submitting the necessary inputs / result sets back to the crowd
- Management Schema to manage the crowd
- Feedback Schema

Task-related facilities: Among many facilities, some of the key task-related facilities provided by the crowdsourcing platform are enumerated as several schema as shown below:

- Summative Schema
- Repository Schema
- Quality Assessor Schema
- Quantity Assessor Schema

Platform-related facilities: Among many facilities, some of the key platform-related facilities provided by the crowdsourcing platform are enumerated as several schema as shown below:

- Online Schema
- Security Schema
- Easy Interactive User Interface Schema
- Fee Payment Schema

Digitization

Digital health records play a vital part in the development of Health Centres in many progressing countries. And hence, the applications are spawned across every rural health clinic in such countries. Many thousands of hard copies of pages of

health records are generated on a weekly basis from these health centres, which makes it cumbersome to both share and analyze. Thus the resources like computer terminals and the access to the electronic report accessible in the clinic seems to be an immediate and a smart solution for such problems. However, rural areas in progressing countries typically lack the general foundation needed to support technology-dependent solutions to such issues [10]. Therefore, it results being in more impractical and expensive to have additional supporting technology. On the contrary, the lack of resources and/or education in handling digital technology reflects in sluggish approval in that region.

Even though, some researchers in their studies inferred that there is still a pertinent need of having paper copies in store [9][11][12], the alternate approach still exist to have an automated digitized solutions subsequent to the availability of data in a repository, and thus to avoid an instrument in the clinic to have capabilities of being a direct-to-digital technology based system. However, the process of digitizing health records finds many hindrances that obstruct the whole system of digitizing of health records. Eventually, it makes a system to be an inevitable process which is just relying directly on the capabilities of human data entry.

Recent studies have investigated the question of who should be doing this data entry and have evaluated digitized results based on the options like cost, speed, and quality. One of the options in such studies have proposed to hire a local nurse to use a computer collocated with the doctor at the rural clinic. These methods resulted extremely costly to develop and further they introduced workflow bottlenecks into the clinic preventing the collection of complete records.

Though, in one of the options, a trained medical transcriptionist digitizes the forms in bulk from the paper, it was found that such systems are accurate, less expensive, but too slow when the number of records grows large.

Ultimately, a generalised approach of digitizing is incorporated which eventually depends on microwork. As a result, the accurate digital records are obtained rapidly, but results in uneven performance and has several queries about the overall system robustness.

Digital Microscope Imaging System: A typical Digital Microscope Imaging System as in Figure 1, includes several components as shown below:

- Optical Microscopy: It understands the process of performing imaging using microscope.
- Data acquisition module: The images are recorded that are produced by the devices such as CMOS. Subsequently, this module sends these images to the storage devices through an interface such as graphics card interface or USB interface.
- Digital image processing.
- Software control module: It is the heart of the whole system which not only controls the capturing process of images, but also processes real-time digital image applications to enhance the quality of image.

The studies have shown that the digital images can be managed in real-time using computer monitors. Digital microscopic imaging systems use several digital image processing methods, and thus can capture more sensitive images and display the image details. The fact that microscopic digital imaging technology has significant technological merits makes to be used and/or incorporated in a variety of electronic microscopes. The configuration of such a digital microscopic imaging system is as shown in Figure 1.

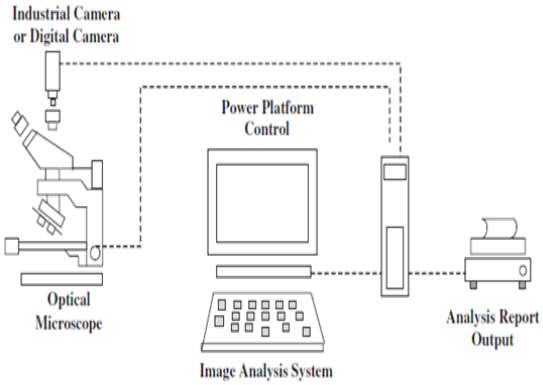

Figure 1: Configuration of modern digital microscope imaging system

Advantages of Digital Microscopic Imaging: Digital microscopic image technology extends the benefits of traditional microscopy by integrating the microscopy, image procurement, with the PC that controls and performs the entire imaging process, including picture obtaining, examining, preparing, and data storage. Picture obtaining and handling innovation happens to be the center of any digital microscopic imaging technology.

Existing digital image procurement devices come in three unique classifications:

- Analog cameras in addition to video catch card
- Consumer grade computerized cameras
- Professional grade computerized cameras

Professional grade computerized cameras are the most well known choice in these classifications that are commonly found in digital imaging microscopy systems. The rapid advancement of more intense PCs makes the digital microscopic images to be adequately and proficiently prepared and analysed.

However, Image investigation and preparing can be customized to use sophisticated commercial microscopic image processing software packages that are all around composed with variety of helpful functions, give both straightforward geometric estimation and refined

examination to recognize the relationship among the complex geometric structures. This kind of software is also equipped with the total space alignment to guarantee the most precise estimations and the highly developed image segmenting technology, helping the spectators to differentiate the overlapping objects, detect the contours and shapes of the small objects, identify similar objects or groups, and classify or mark the various objects with various colors convincingly. To maneuver the data and present it in various formats, several functions can be applied to perform advanced analytics through the features like utilize the spectrum diagram, spectral profile, pseudo-shading, three-dimensional surface shape.

Yet another benefit of associating the microscope to a PC is that as it produces digital pictures, the fraternity of research scientists and clinicians has the liberty to apply different image handling and analysis software to get information for further investigation for assortment of purposes.

The studies have witnessed new developments in microscopic imaging technology, numerous new microscopic imaging techniques have been created and tested that intend to obtain the images with high resolution and expansive field of profundity, and also in three dimensional stereoscopic formats. Hence, the new microscopic imaging systems and the procured images allow the clinicians to perform dynamic, non-caustic, and non-intercession in vivo (real time) tests in the biomedical research and clinical practice. Among numerous new advacements found in the literature in this field, some incorporate the Coexistence of a expansive field profundity and high amplification power, comprise of Three-dimensional imaging and *In-vivo* detection.

In the work proposed, the technician at rural area would be preparing the required slide and generate a digital image through the digital microscope. The Microscopic magnification required for the work is 10X-100X.

LITERATURE REVIEW

In the work proposed in [6], the achievement and transmission of biological specimens discovered through minimal-cost microscopy are fed to a server that would be seen and investigated by autonomous individuals of a crowdsource group. The study proposes the system subjected to quality control and the populaces that don't have admittance to medical investigative facilities are expected to utilize the full preferences of medical analyses. In such a system, a Smartphone is outfitted with a minimal-cost microscope interface which empowers health-care laborers to achieve digital images of biological specimens, microbes, or tissue cultures that are then forwarded to a cloud server, These image information are then made accessible for specialists to give a consent on the imaged specimen through crowd-sourcing. The suggestions of crowdsourced speacialists are basically relying on their scientific peer position, professional education and on their history of assistance and peer ranking within the crowdsourcing community. Hence, in their study, the different opinions thus obtained based on the nature of the sample provided, are weighed by the crowdsourcing software engine which eventually displays the conclusions to the starting health-care worker. Hence it is evident from such studies that the minimal-cost microscopy in mix with crowdsourced distinguishing proof of biological specimens may turn out to be a major step in e-HC research.

In the studies conducted in [5], they built up a framework called Crowd Help, for constant patient appraisal which utilizes portable electronic triaging achieved by means of crowdsourced and sensor identified data. The major objective of their work is to manage professionals to receive emergency data they requirement for setting themselves up to perform an auspicious and precise treatment of their patients even before dispatching a reaction team to the occasion.

Several studies such as in [5], propose an extended data assembly and sharing tools which utilize crowdsourcing to convey more precise data to calamity managers more rapidly than should be possible with conventional systems. The major goals of such system are to help people within the radius of a natural disaster who are partly talented to send content, pictures, recordings, areas, and depictions of what they see. Such systems then investigates the information received, validates the sender, expels inputs that are liable to be malevolent, bunches reports by sort, earnestness, or area as preferred by the human administrator, then shows the outcomes on a map along with proposals to the administrator concerning what kind of assistance is generally required. These systems are equipped with the smart phones that gather extra sensor data for future investigation by the concerned proficient debacle administration associations. Therefore, as we are as of now in an enormously productive stage for the Health 2.0 technologies which are progressively turning into a standard of work in various health and readiness organizations, the significance of e-Health, as a major aspect of the rapidly establishing Web 2.0, is bound to increment significantly throughout the following decade.

The studies performed in [2], discusses how crowdsourcing can be utilized in the resource allocation for healthcare support, creating a venue for potential donors to contribute. However, it was shown that certain issues such as healthcare information security, patient privacy, donation management, crowd motivation, implementation of micro donation, and sustainability are usually encountered during the design phase of any crowdsourcing system. Therefore, several studies are existing in the literature that has designed systems by considering each of these issues.

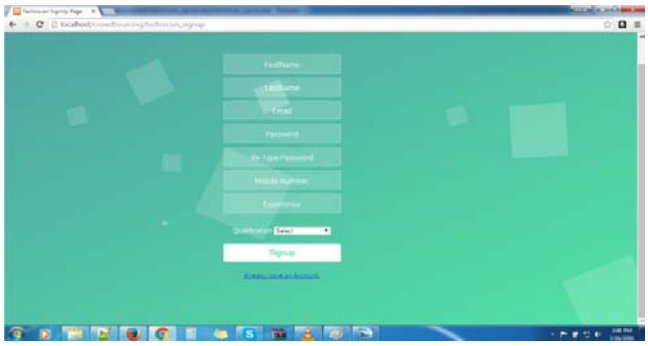

Figure 3: Technician Signup

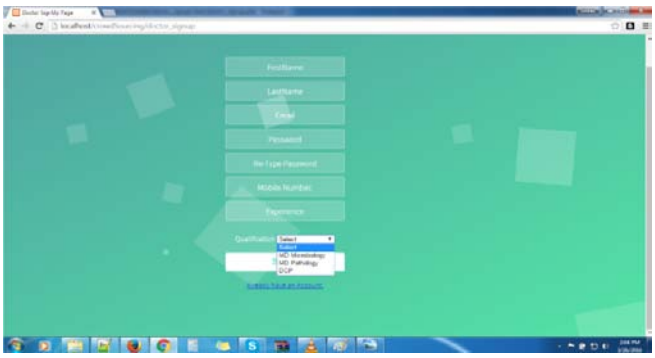

Figure 4: Expert Signup

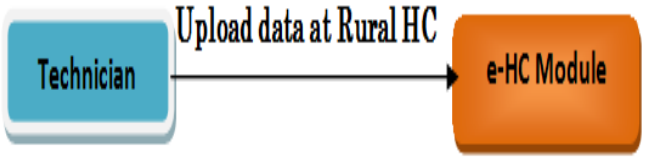

Figure 5: Updating data at e-HC Module

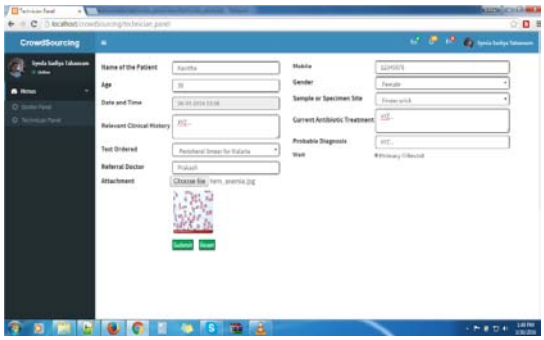

Figure 6: Technician Dashboard

PROPOSED SYTEM

In the work proposed, the digital images of biological specimens are transmitted to an e-Health Care (e-HC) module. The digital images are then made accessible by means of crowdsourcing, for specialists to present their accord on specimen that was crowdsourced. The suggestions of experts are then maneuvered based on their qualifications, and their experience in contributing to the society of crowdsourcing. Based on the nature of the specimen, the various opinions collected are then measured by an e-HC module which eventually presents the compiled suggestions to the technicians in the crowd in an e-HC setup.

Methodology and Implementation

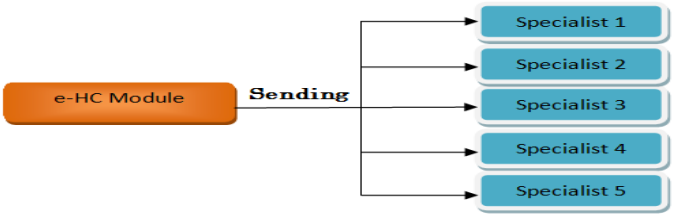

Figure 7: Broadcasting the Crowdsourced Task

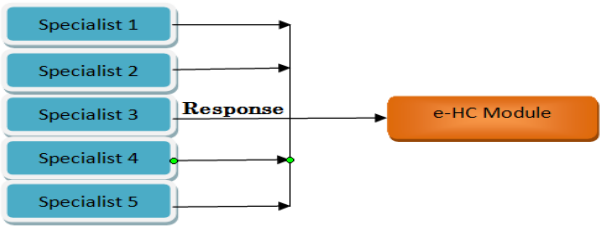

Figure 8: Aggregation of the Crowdsourced Task

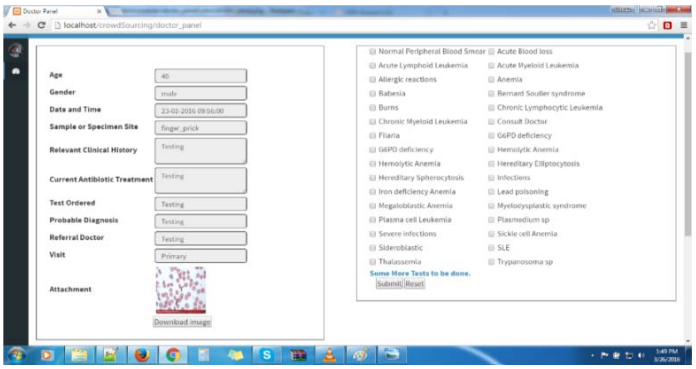

Figure 9: Expert Dashboard-1

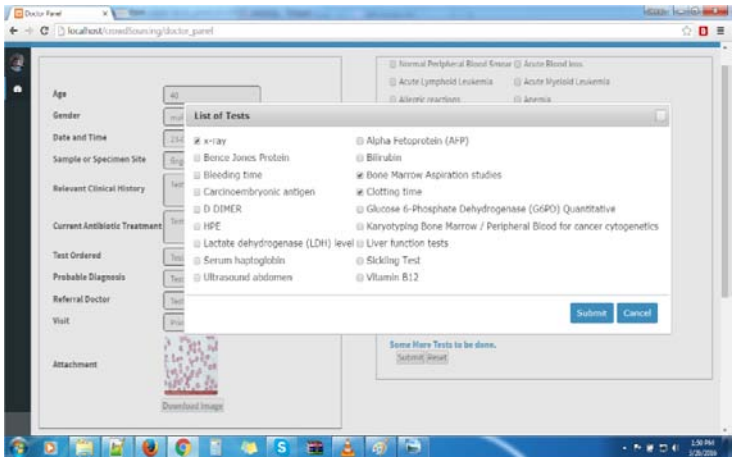

Figure 10: Expert Dashboard-2

Step1: Providing an enrolment schema in a crowdsourcing platform for the crowd to enroll themselves.

In the work proposed, the enrolment of Technicians and Specialists is performed through the proposed e-HC Module as shown in the Figure 2, 3 and 4.

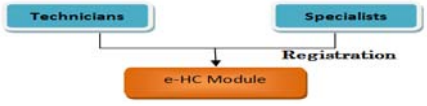

Figure 2: Registration at e-HC Module

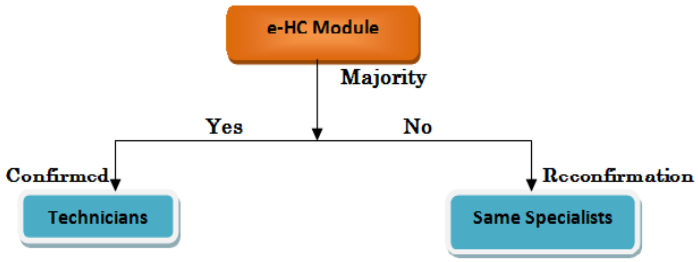

Figure 11: Decision Making

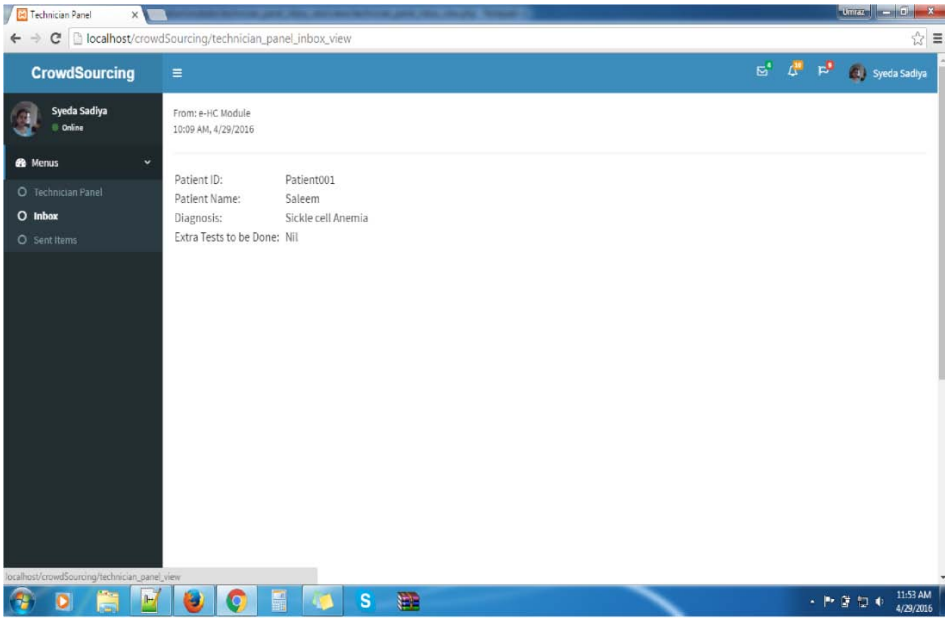

Figure 12: Conclusion of Crowdsourced Task

Step 2: Uploading crowdsourcing task to the Crowdsourcer.

In the work proposed the image data is uploaded by the Technicians to the e-HC Module, which is considered as a Crowdsourcer. This operational step is as illustrated in the Figure 5 and 6.

Step 3: Broadcasting the crowdsourcing task to the crowd. In the work proposed, based on the availability of the experts in the crowd, the e-HC module sends the crowdsourcing task to the Experts / Specialists. In case, the crowdsourcer does not receive any feedback within a threshold of time span from the Experts / Specialists, it resends the tasks to different experts in the pool to speed up the process of synthesizing the crowdsourcing task as demonstrated in the Figure 7 and Figure 9. However, the threshold is not chosen based on any parameters that may cause transmission delays due to inherent features of network.

Step 4: The mechanism of integrating the results from the crowd after receiving their views back to the source is as demonstrated in the Screenshot shown in the Figure 8, 9 and 10. In the work proposed the Expert's dashboard is implemented to receive / send the data / reports from / to the source.

Step 5: Giving a summative mechanism to summate the results of a crowdsourced task. The conclusion of such crowdsourcing task from a crowd is sent to the crowdsourcer for further confirmation, and may likewise be partly sent to the crowd as component of the feedback.

In the work proposed, aggregation is done by comparing the majority of results by using the Brute Force String Matching Algorithm, subsequently, the same is sent to the Technicians, participating in the crowd. As a result the e-HC module sends the notification to the patient registered under the technician to collect the report from e-HC. In case if the consensus of the majority does not conclude or confirm the disease then the same shall be resent with the aggregated results to all the experts from the Medical field in the Crowd as demonstrated in the Figure 11 and 12.

CONCLUSION AND FUTURE ENHANCEMENT

Having a Universal Health Care in the country is one among the various assets that are pertinent to the growth of any nation. Recent studies have shown that the accessibility and availability (Fewer medical practitioners) of health resources, psychological health programs and healthcare services in rural

areas regularly mean less precaution consideration and longer reaction times in crises. Low-cost microscopy in mix with crowdsourced recognizable proof of biological specimens may end up being a stage in this course. Crowdsourcing is one of the major sources of exploiting the knowledge into reasonable and resourceful action that helps the people in the societies that don't have admittance to full-fledged health care systems as against the urban dwellers.

In the proposed system, the digital images of biological specimens are transmitted to e-HC module. Implementing the crowd on a cloud, incorporating the intelligence using machine learning algorithms over a cloud for assessing the bacteria, or tissue cultures, or any specimen of a biological disorder with respect to human / or animal diseases over a large crowd remains as a future enhancement.

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