Sensor Grid Based Vision Status Monitoring in Eye Care System

M. Anitha, S. Ravimaran, M. A. Maluk Mohamed, and M. Anbazhagan

***Abstract*—Wireless sensor networks play an important role in various applications including health care monitoring of patients. In health care monitoring various health conditions of patients are monitored by using bio medical sensor including the field of Ophthalmology for monitoring oculomotor behavior, cognitive visual function and vision deficiencies in diverse environments for various post surgical treatment. The Bio sensors deployed in this environment are resource constraint in nature with limited processing and communication power. The work have proposed Sensor Grid architecture called sensor grid based vision status monitoring in eye care system for monitoring the vision status of different groups of eye patients to provide a platform for ophthalmologists to share computational resources to facilitate quantifiable eye-movement analysis, diagnose and treat abnormalities or ocular disease in clinical situations to reduce the dormant propagation of eye diseases. The paper proposes a novel unique simulated model integrating ophthalmological sensors (bio sensors) with the grid to process and store the collected ophthalmology data to achieve better vision prediction rate in ophthalmological field with low latency, increased throughput and proper load balancing across the sensor grid.**

***Index Terms*—Grid computing, middleware, ophthalmology, sensor grid, Wireless Sensor Network.**

I. Introduction

Wireless Sensor Network (WSN) [1] is a set of small, autonomous devices, working together to solve different problems. The integration of small and cheap microcontrollers with sensors can result in production of extremely useful devices, which can be used as an integral part of the sensor nets. These devices are called sensor nodes. Nodes are able to communicate each other over different protocols. However, there are some limitations with the wireless sensor network such as transmission power, low bandwidth, lower speed, more complex to configure, affected by surrounding. Main Issues, addressed by communication among nodes, include power management, data transfer, and mobility patterns. To overcome these problems with WSNs we can integrate both Wireless sensor network and grid environment which extends the grid computing paradigm for sharing of sensor resources in WSNs.A Sensor Grid [3] integrates wireless sensor networks with Grid computing [7], [8] concepts to enable real-time sensor data collection and the sharing of computational and storage resources for sensor data processing and management. It is an enabling technology for building large-scale infrastructures, integrating heterogeneous sensor, data and computational resources deployed over a wide area, to undertake complicated surveillance tasks. Sensor networks are limited resource systems with limited power and bandwidth. A grid, on the other hand, has huge quantities of bandwidth and processing power; power saving is not a requirement of the system. In the field of ophthalmology [9], vision researchers use eye tracking to study oculomotor behavior, cognitive visual function and vision deficiencies. Quantifiable eye-movement analysis enables new diagnostic markers and identification of disease at a much earlier stage of progression. Current methodologies that rely on observation can be automated, reducing variability. Eye tracking helps vision researchers to better understand eye movements and eye movement problems, and to develop means to prevent, diagnose and treat abnormalities or ocular disease in clinical situations. In order to analyze the existence of the eye deficiencies in earlier stage itself, the ophthalmologists needs an environment where the eye related data's can be collected from the eye patients who are located globally. This can be done easily when the ophthalmologists are connected with wireless sensor grid environment.

The reason behind the purpose of eye tracking is mainly due to the consequences such as to identify the eye problems if a person can be affected by some hereditary eye diseases. Some people sitting in the air conditioned rooms will be affected by dryness which will lead to increase in eye pressure. The diabetics' patients are not aware of their eye by Diabetic Retinopathy, where this disease needs the frequent eye monitoring.

So the concentration of this paper mainly focuses on the prediction of eye deficiencies in an earlier stage itself. This paper proposes a Sensor Grid Based Vision Status Monitoring in Eye Care System for monitoring the vision status of different groups of eye patients to provide a platform for eye specialists and researchers to share information with distributed database and computational resources to facilitate quantifiable eye-movement analysis, diagnose and treat abnormalities or ocular disease in clinical situations. This system reduces the demands of the hospital services and the emergency situations are handled before hiring to the hospital. The sensor data are published through mobile phones. The ophthalmologists and eye patients can retrieve the data whenever it is necessary through internet. The remaining of this paper is organized as follows: Section III explains our system model while section IV explains the implementation with middleware support of our Sensor Grid Based Vision Status Monitoring in Eye Care System. Section V provides a performance evaluation and we conclude in Section VI.

Manuscript received April 5, 2012; revised May 10, 2012.

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II. Background and Related works

A number of recent research efforts focus on wearable systems for Eye tracking. We compared vision status monitoring in eye care system with The Tobias TX300 Eye Tracker sets a new standard for remote eye trackers. The Tobias TX300 is a very high precision, robust eye tracking. In this system the patients must appear physically for analyzing the eye movement. It doesn't provide any possibility to identify the eye deficiency in its earlier stage. But in our system it doesn't need to appear any of these systems. Simply the eye deficient has to wear the spectacle which is embedded with the sensor and it is interconnected among wireless sensor network [1]. Our system provides mobility for both medical advisor and the eye deficient, when compared with The Tobias TX300 Eye Tracker [2]. Next we compared with the Arogyasree [4] where it is a context-aware, P2P data grid framework for mobile telemedicine. This Internet-based scalable system integrates multiple hospitals, mobile medical specialists and rural mobile units/clinics to form a large virtual enterprise. Here they concentrated on measuring vital health parameters such as blood pressure, electrocardiogram, blood sugar, weight, etc.In our proposed system we have measured vision changes alone. In healthcare monitoring using smart objects [5], sensors are attached to the patient's body. The vital parameters collected by the sensor are transmitted to the nearby mobile device which is a part of the grid. In the grid, the relevant blood related parameters are sent to an appropriate node which contains Software as Service (Sass). This technique was compared with our system, where the grid will do pattern matching especially with the eye details collected from the sensor and will analyze the abnormalities. The patient monitoring using sensor grid Architecture framework [6], [7], [8] is a hybrid architecture that combines WSNs and grid-enabled software tools that support the storage, processing and information-sharing tasks. Our system uses the grid enabled environment for doing load balancing, resource sharing among diverse environment. The problem of many of the existing system needs a nodal centre, health worker which is created in a local hospital in the remote areas where doctors and patients directly interact at the big hospital. The most important thing to be considered here is the sudden vision changes in a person cannot be determined in its earlier stage, unless the person went for regular check up for about six months per year. So we need a system which will intimate immediately the sudden vision changes in a person to reduce the dormant propagation of eye diseases.

To overcome these problems we have developed a Middleware [11], [17] support in order to collect the vision changes of a person immediately. The middleware will provide a way to interact with the patient and the specialists. The collected vision details from the sensors are transferred to the Grid environment to provide resource sharing among various WSNs which will be used to facilitate quantifiable eye-movement analysis, diagnose and treat abnormalities or ocular disease in clinical situations. Our system is compared with other healthcare techniques in order to provide efficient response to the enormous amount of requests from the eye patients/doctors from various diverse environments by using sensor grid.

III. Sensor Grid Based Vision Status Monitoring in Eye Care System

Our proposed architecture provides a platform for ophthalmologists and researchers within the sensor grid consortium to share information in distributed databases and computational resources to facilitate quantifiable eye-movement analysis diagnose and treat abnormalities or ocular disease in clinical situations and care for eye patients within the grid.

A. System Architecture Of A Sensor Grid

The architecture of a wireless sensor grid, which comprises of different servers that are geographically distributed and belongs to different divisions of organizations, connected through a sensor grid. The sensor grid is used to run the existing application on the available machine on the grid rather than locally. More probably it is used for application designed to split its work in such a way that the separate parts can execute in parallel on different processors. The eye patients' environment are equipped with wireless sensor nodes for retrieval of data from sensors (attached with the spectacles), which transfer the collected data to pattern matching server 2. The Globus Toolkit 4 (GT4) is chosen to form an internet data grid and implement the grid middleware functions. The proposed architecture consists of the following three servers namely medical repository server 1, decision maker server 2, information conveyor among specialists for alerting server 3 and a wireless sensor network deployed near the eye patients environment. To enable the service request a graphical user interface is embedded and it is used, where the processing is done by a GPRS enabled mobile device.

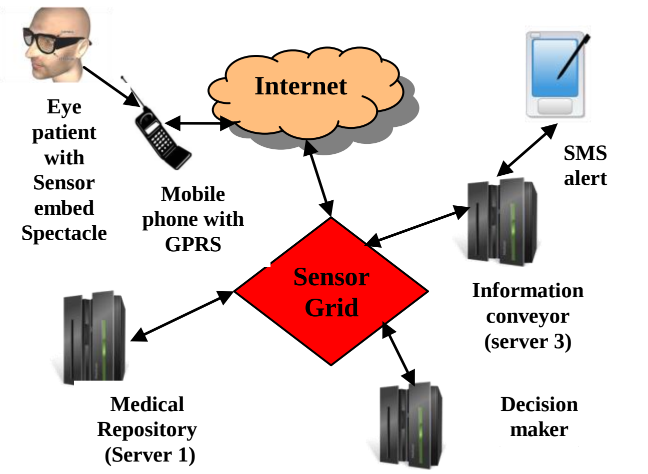

Fig. 1. Sensor based vision status monitoring in eye care system

B. Sensor data

Ophthalmologists are physicians who diagnose and treat diseases that affect the eyes. They also perform eye surgery. These doctors may also provide routine vision care services, such as prescribing glasses and contact lenses. Changes in vision, blurriness, blind spots, halos around lights, or dimness of vision should always be evaluated by a medical professional. Such changes may represent an eye disease, aging, eye injury, or a condition like diabetes that affects many organs in our body.Inorder to recognize these eye problems the physicians need to know the vision status. The sensor which is embedded in the spectacles will collect necessary data of an eye with the following parameters. They are DV: distance vision,NV: Near vision,OD:oculus dexter(right eye),OS:oculus sinister(left eye),OU:oculi uterque(both eyes).The vision changes will lead to some of the eye problems such as Presbyopia,Cataracts ,Glaucoma, Diabetic retinopathy, degeneration, Eye infection, inflammation, or injury,Floaters,blindness, detachment, Optic neuritis, Stroke or TIA,tumor.

C. *Medical repository (server 1)*

In the figure 1, the sensor data collected from the sensor node consists of patient id and power details of an eye patient. They are stored in the medical repository server 1 for the future accessing by eye patient/specialist. By storing and managing all the data that come from the sensor networks, the database provides an excellent data-centric platform for patients to exploit the sensor data resource. The grid technology is used here in order to collect massive amount of data where its physical environment is limited processing and communication ability is very low.

D. *Decision Maker (server 2)*

With the necessary details collected from the sensor, the Grid now performs the pattern matching with existing database (server 1) where it enquires the normal and abnormal vision status. The large amount of collected physiological data will allow a quantitative analysis of various conditions and patterns. Data mining is a complex process that allows discovering unsuspected meaningful knowledge in large databases. The process could be classification, clustering, association rule mining, attributes, etc.The decision maker performs two jobs i.e. normal and abnormal vision identification.

Case 1: Normal Vision

The existing database (server 1) has already store the vision status of the eye deficient. Then whenever the sensor collects the sensor data (vision details) it automatically does pattern matching with the Decision maker server 2 with the current vision status. If the matching is true with the compared data in the server 2, it assumes that the vision of the particular eye deficient is not changed and it is considered as normal vision. The denominator denotes your eye power and the numerator denotes the eye power of a normal person. The eye power 6/6 is considered normal vision.

Case 2: Abnormal Vision

If the matching is not true, then it is considered that the vision of an eye patient is changed and it will leads to some other eye problems. If one wireless sensor network couldn't do the process it is automatically processed by another network which is done by the grid. The parallelism and load balancing are automatically enabled according to the situation of the request from various diverse environments.

E. *Information conveyer (server 3)*

On knowing the seriousness of eye patient, abnormal vision details are conveyed to the doctor through the mobile. Then, the doctor prescribes medicine or alerts the patient to take immediate action. If the particular doctor couldn't do the necessary prescriptions then the processes will automatically performed by another wireless sensor network with the help of grid support. In our implementation, the grid portal serves as an interface between an end user (e.g. a clinician or a researcher) and the grid. At the client side, an end-user accesses the grid portal via a web browser. After user authentication (login/password), the end-user can make use of the services provided by the grid.

IV. MIDDLEWARE ARCHITECTURE FOR VSM EYE CARE SYSTEM USING SENSOR GRID

A middleware layer is a novel approach to fully meeting the design and implementation challenges of wireless sensor network technologies. A complete middleware solution should contain a runtime environment that supports and coordinates multiple applications, and standardized system services such as data aggregation, control and management policies adapting to target applications, and mechanisms to achieve adaptive and efficient system resources use to prolong the sensor network's life. The sensor in the spectacle can communicate the vital measurements of an eye to a mobile device which is enabled with the technology such as Zigbee or Bluetooth. In the figure 2, the middleware architecture of the Sensor Grid Based Vision Status Monitoring Eye Care System explains that the data collected from the sensor undergo different jobs with the help of grid support. The middleware services are messaging services, sensor management services, dose discovery services. Knowledge database contains patient and doctor profile, patient eye monitoring reports. The grid environment store the details according to the patient id.Patient/Doctor can receive SMS (wireless messaging) of any abnormalities and provide appropriate prescriptions. The developed middleware for this system will provide services such as load balancing, response time decreases, reliability and security etc.

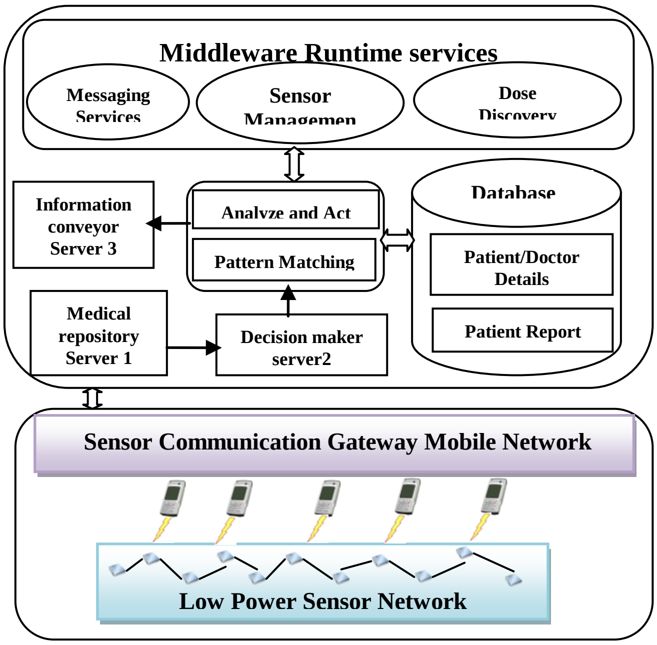

Fig. 2. Middleware Architecture

A. *Job scheduling*

In the Sensor Grid Based Vision Status Monitoring Eye Care System, when the job (sensor data) collected from various environment is submitted to the grid, the *job/resource broker* will broke down the jobs into any number of individual jobs. These jobs are scheduled by job scheduler and jobs are executed in parallel on different machines in the grid. The scheduler will automatically finds the most appropriate machine on which to run any given job that is waiting to be executed. Schedulers react to current availability of resources on the grid.

B. Load balancing

When the sensor data are submitted to the grid system, it is responsible for any machine that becomes idle would typically report its idle status to the grid management node. This management node would assign to this idle machine the next job whose requirements are satisfied by the machine's resources. Scavenging is usually implemented in a way that is unobtrusive to the normal machine user. If the machine becomes busy with local non-grid work, the grid job is usually suspended or delayed. This situation creates somewhat unpredictable completion times for grid jobs, although it is not disruptive to those machines donating resources to the grid.If hundreds of jobs are performing in one machine where the resource availability of that machine is low, the grid system will automatically shares the jobs with other machine in order to execute and to get the output.

C. Reliability

The systems in a grid can be relatively inexpensive and geographically dispersed. Thus, if there is a power or other kind of failure at one location of the doctor end, the other parts of the grid are not likely to be affected in diverse environment of hospitals. Grid management software can automatically resubmit jobs to other machines on the grid when a failure is detected. In critical, real-time situations, multiple copies of important jobs (sensor data) can be run on different machines throughout the grid. Their results can be checked for any kind of inconsistency, such as computer failures, data corruption, or tampering.

D. Security

The middleware developed for this application will provide security services such as authentication, authorization, and encryption. A grid resource is authenticated before any checks can be done as to whether any requested access or operation is allowed within the grid. Once the user has been authenticated within the grid, the grid user can be granted certain rights to access a grid resource. The authentication is given by patient id and doctor id in a diverse environment. This, however, does not prevent data in transit between grid resources from being captured, spoofed, or altered. The security service to insure that this does not happen is encryption.With the symmetric encryption or asymmetric encryption, the sensor data and the doctor's alerts, prescriptions are secured where the security threats are avoided. The various forms of digital certificates or proxy certificates are used in order to protect the data from unauthorized users.

E. Communications and response time

Our middleware may include software to help jobs communicate with each other. For example, a sensor application may split itself into a large number of sub jobs. Each of these sub jobs is a separate job in the grid. However, the application may implement an algorithm that requires that the sub jobs communicate some information among them. The sub jobs need to be able to locate other specific sub jobs, establish a communications connection with them, and send the appropriate data. Here the communication is needed for a particular job because the sensor data can be splitted into sub jobs in order to execute and to get result. The open standard Message Passing Interface (MPI) and any of several variations is often included as part of the grid system for just this kind of communication. The response time is decreased with automatic sharing of resources with idle machines whenever the user machine is busy. The users will have immediate response for a particular job when the jobs are broken down and submitted to other machines. The response time will be about some fraction of seconds

V. Performance Evaluation

The performance of our proposed system is evaluated according to prediction rate of vision changes. The identification of abnormalities in earlier stage itself can help to avoid dormant propagation of the disease in the eye patient. To see the performance realization, in the figure 3 and 4, we have compared our proposed system with eye tracker system.

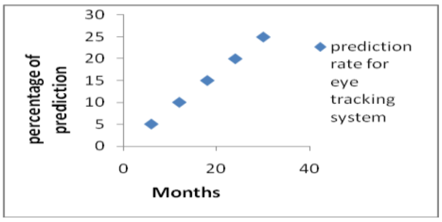

Fig. 3. Performance of Eye tracking system

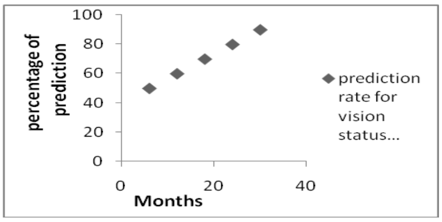

Fig. 4. Performance of Vision Status Monitoring in Eye care system

The parameters are routine eye check up once per six months in a year and percentage of increase in prediction rate. Here the prediction rate of abnormalities increases with our proposed system rather than eye trackers. Since the eye tracking system increases the prediction rate during the regular checkups (once per six months in a year). But in the proposed system the prediction rate increases within the six months. The dormant propagation of eye diseases, decreases with increase in the prediction rate. Finally the response time is decreased to a level to meet the user's requests to do a task with the assistance of sensor grid environment.

VI. Conclusion

Our proposed architecture aims to provide a grid-enabled network for eye Vision Status Monitoring where seamless sharing of different groups of eye patients' vision information. The system supports analysis of eye patients to know the major eye diseases in an earlier stage itself. Information from the distributed databases is made available over the Internet to provide access to eye patients and ophthalmologists. This technology will pave way for enabling to give effective early alerts to the specialists and caretakers about eye patients' vision status. This enables the ophthalmologists to share the databases of different groups of patients. The data are published via web servers. The eye patient and the ophthalmologists are registered for their mutual communication. In future this paper can be concentrated on the security issues of this grid enabled system.

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