IoT-Based Skin Monitoring System

Shuchi Bhadula, Sachin Sharma

Abstract: The numbers of patients with skin diseases reported a dramatic increase which is a major concern and must be dealt with. The method of diagnosis is always based on physician's observations and experiences. Many common symptoms such as side effects, allergies and even risks of skin cancer can be seen in someone following misdiagnosis, delayed diagnosis and failure to diagnose. The evaluation of skin changes is crucial to the correct diagnosis during follow-up. Through technological advances and partnerships, skin disorders can be identified and predicted and medical diagnosis outside physical limits are made. The article proposed an IoT-based skin surveillance system that facilitates the monitoring of skin patients in remote locations. In a diagnostic device for real-time skin monitoring and analysis, the proposed system architecture can be applied. A sensor fitted medical carriage is proposed in a remote location to treat individuals suffering from a common skin disorder. The system is also designed to research the impact of climate change on the disease through environmental sensors and provide pre-alertfor prevention. This addresses the many problems that people in remote areas without restricted treatment facilities face.

Keywords: Internet of Things, cloud computing, skin monitoring.

I. INTRODUCTION

Skincare is a potential area for development in the field of medicine that requires a lot of research The number of patients with skin-related problems increases more rapidly. It is often totally unknown to people that they have even been at risk for skin cancer. The best strategy for early detection of skin diseases is to promote and enable more efficient skin monitoring systems.Advanced Internet of Things (IoT) innovations [1] and Cloud Computing (CC) [2] are likely to change the healthcare sector. Although IoT and CC integration is a new platform for current medical applications [3], more focus is needed for the field of remote health surveillance [4]. An IoT-based, cloud-enabled remote-skin monitoring system definitely contributes to autonomous, real-time diagnosis and skin disease prevention. It is expected that IoT-based skincare services will be cost effective, improve the quality of life and provide real-time supervision.This work will contribute to the development of a perfect platform for skin care, contributing to the early detection and diagnosis of skin conditions, to adverse treatment of skin problems and to improved quality of life.

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A program to take care of patients on their locations is a potential way of addressing the problems faced by people in remote areas, with or without restricted skin care facilities. In this paper, we proposed an IoT-based skin surveillance system that helps people living in remote areas suffering from common skin diseases, diagnose and track a group of expert skin practitioners from other countries. An IoT-based skin monitoring infrastructure is proposed that links the entire system with intelligent objects and constantly tracks and controls patients ' skin. At the location where there are common skin diseases among people, a skin care van with sensors is deployed.Van gives space to collect skin data from patients through sensors and move them to cloud platforms from which a doctor can access them. A mobile application services include treatment, drugs, and appointments to patients. Each patient is given a specific username and password for every future contact and authentication. In the case a patient's referral is received, monitoring services are provided on request. The installation of environment sensors at the same defined position is an important component of this method.In order to produce inferences and some concrete patterns, environmental data collected can be analyzed with data on skin conditions. This will help predict the environmental effects on skin disease and can be further used to provide precautionary action alerts. The technique allowed by the IoT cloud delivers power efficiency, consistency, reliability, interoperability and so on. The whole program thus helps prevent and treat patients with the best technical and medical services at a remote location.The paper is organized as follows: Section II, discusses the related work in the field of IoT aided healthcare. Section III describes the proposed methodology and scenario. Section IV discusses the proposed architecture of an IoT-based skin monitoring system over cloud platform. Case study followed by result analysis and discussions is explained in section V and VI respectively. Finally, Section VII concludes the paper.

II. LITERATURE SURVEY

With healthcare applications, the Internet of Things technology can be of great benefit. Different types of sensors can be used to assess and track human body medical parameters [5]. Through his research, McGrath and Scanaill [6] describe the various wearable sensors used for personal health movement through detail. Many wearable devices with sensors are now available on the market which measure various parameters, such as the heart rate, pulse, blood pressure, body temperature, respiration rate and blood glucose levels [7].Another new IoT system that has a lot of promise is skin tracking patches that can be put on the skin like a tattoo. The patches can be extended and unregulated, also at low cost. The patient can use these for a long time to track continuously a critical health parameter [8].

The electronic components are incorporated into the rubber structure and are capable of transmitting sensor data through wireless media. By using IoT and advanced wireless technologies, patient health parameters can be broadcast to clinicians in real-time [9,10]. Several research studies are proposing IoT-based health monitoring systems to predict various types of disease. This section discusses briefly some of the existing systems and models. Ahn et al [11] has a smart chair for physiological signals such as ECG and BCG while sitting. Almotiri et al. [12] proposes a mobile m-health system using wearable devices and a corporeal sensor network to collect patient data in real-time. The details was saved online and made available for patient diagnosis. Accessibility is only given to a particular group. Chiuchisan et al. [13] proposed an intelligent ICU system which alerts and informs relatives and doctors if they notice that their health conditions and body movements are incoherent. The changes in the environment in the room are also essential intimations if necessary to ensure precautions. Shuchi et al. [14] discusses the classification of skin diseases using various machine learning methods and their comparative analysis.Gupta et al. [15] introduces a development board approach with Intel Galeleo. You can upload the data collected from the health parameter to the database and access the doctors. This method decreases the pain caused by patients on their health checks during frequent hospital visits. The Healthcare Management System and the extensive data generated from various reports have been studied by Sahoo et al. [16].They evaluated health parameters so that patients ' future health conditions could be expected. Cloud-based Big Data analytics framework uses chance to accomplish the same. The role of IoT in healthcare was investigated by and studyed by Tyagi etal. [17] to bring it into practice. The Cloud offers a cloud-based conceptual framework that allows the sharing of patient medical data safely with their permission. The Cloud includes a network of patients, clinics, physicians and labs, etc., in order to relieve patients from the onerous clinical assistance and address their lack of medical personnel. A assisted living environment makes everyday life and chronic health conditions easier for people with disabilities. Through the use of sensors patients can be equipped through live assistance in real time. Once introduced in the field of healthcare, IoT provides advanced services, such as the collection of vital information from patients through medical sensors, storage and processing of medical data on the cloud platform, and ensuring all-round medical information access or sharing [18]. The healthcare sector's challenges are also an opportunity to develop and incorporate the IoT, thus helping to improve healthcare services. In the field of healthcare there are already a variety of IoT-based technologies and applications proposed. There is still more emphasis on skin health monitoring using advanced technologies such as IoT and cloud. We will focus more on the provision of increasingly accurate, low cost and effective IoT-based skin surveillance systems and architecture.

III. PROPOSED SCENARIO AND METHODOLOGY

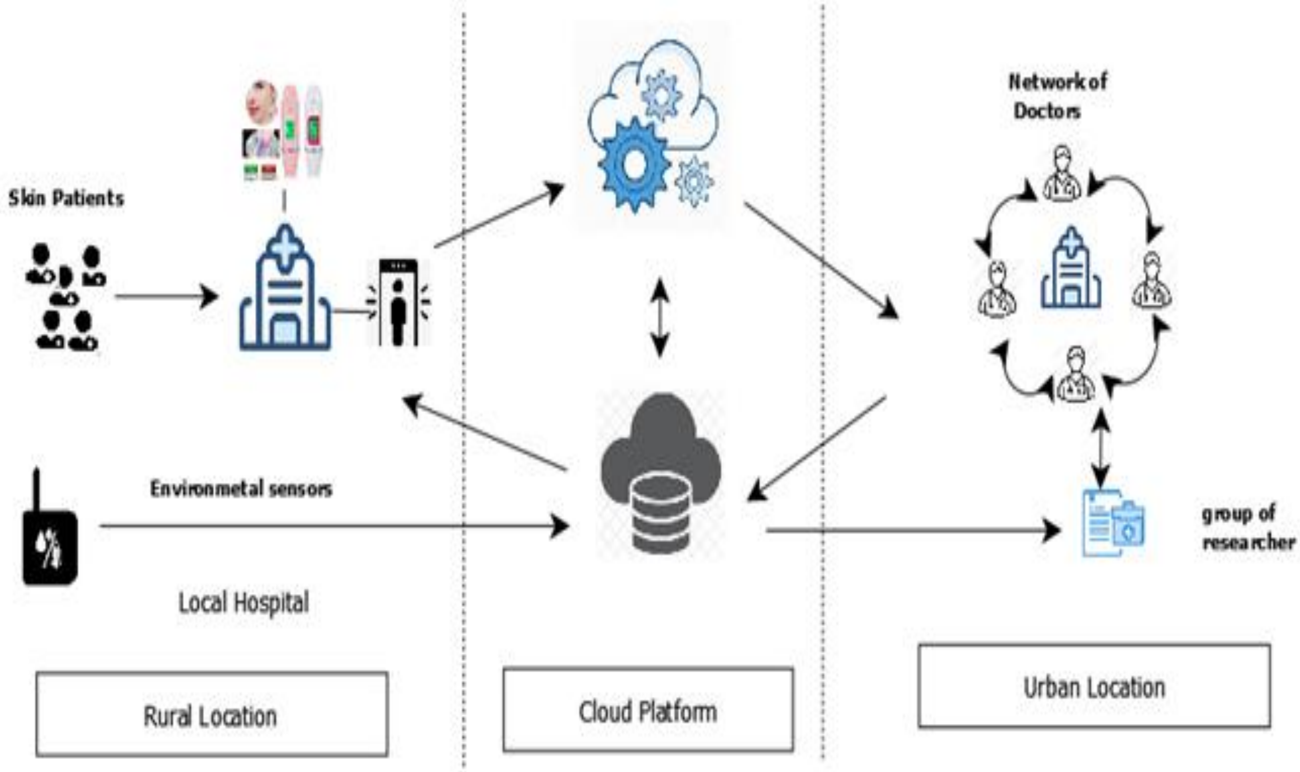

Fig. 1. IoT-based skin monitoring system at remote location.

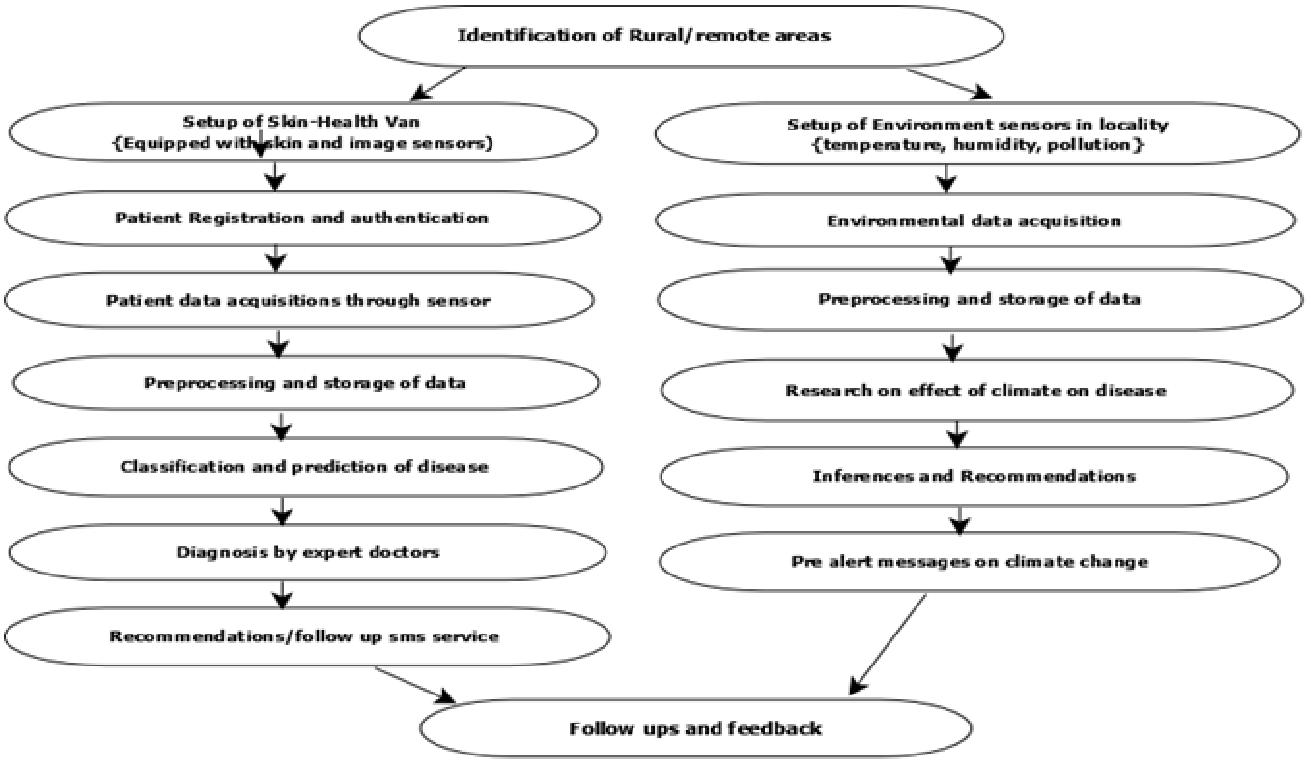

Fig. 2. Methodology used for IoT-based skin monitoring system.

In this paper, we propose an architecture of remote skin monitoring systems based on the IoT paradigm in order to assist rural people, who are affected by skin disorders to benefit from treatments and expert monitoring in different places. Fig. 1 shows the proposed system where a remote location is identified having group of people suffering from a common skin disease. The nearest local hospital will be sent to the designated location, a skincare van with skin sensors (image sensors, moisture level, level of ph, dryness level, sensors of tewl level) fitted. Many weather sensors are also installed at the same location (temperature, humidity, noise, etc.). Skin patients who feels like to go to their local hospital, download a mobile application and registered once. Each individual patient is given a unique username and password followed by skin pictures and parameter values by Skincare Van sensors. Data collected from the sensor is collected and transmitted via cloud-based platform in local databases. Cloud data is delivered for automated disease prediction analysis. The group of specialist physicians is eligible for final diagnosis and treatment to diagnose, forecast outcomes and patient data. The patients are provided with medication recommendations and next appointment details through the mobile app. One module is also used to sensor the local temperature, humidity and pollution levels and send the data to the cloud.Changes in the skin disease of the patient can be investigated and prediction can be predicted, with changes in environmental parameters. Once the right conclusions have been made, a pre-alert(s) can be given with precautionary and preventive measures for patients in this particular area. Facilities such as ambulance and hospitalization are also given in case of severe skin problems if patients need continuous monitoring and treatment.The proposed methodology for IoT-based skin monitoring system is depicted through Fig. 2.

IV. PROPOSED ARCHITECTURE

The section proposed an architecture of IoT-based skin monitoring system. Fig 3. Shows the four main components of the proposed architecture :

i. ***Sensor platform***: to collect patients' skin data through sensors.

ii. ***Cloud Infrastructure***: to provide application services for storage, processing , analyzing etc.

iii. ***Optimized analysis using computational intelligence:*** to classify and analyse the data for decision making.

iv. ***Fast decision making***: to recommend medication and followups.

All the components are explained in brief as follows.

i. Sensor Platform

A skincare van fitted with a local (skin) sensor and server is a sensing device. Data such as high resolution images of the skin, skin ph levels, Hydration and Trans epidermal water loss are obtained by the sensors, etc., depending on the specific symptoms of the patients in the skin. A local server is a server compliant with several local networks, including Wi-Fi and LTE. A local server can be used. It has features such as GPS, Wifi and the SQLite databases. This provides a variety of functions.The local server can be connected to the IoT-based system sensor and the cloud infrastructure.

These skin data can also be supplemented by additional data such as age, gender, place, past history of skin problems and so on, for predictive analysis and precise disease inferences.

A further collection of sensors is also mounted at the specified site, namely environmental sensors.These sensors capture environmental information including temperature, humidity and the level of pollution at this location continuously and relay the information to the local server. The changing trends of skin diseases for preventive intervention in future can be explored these parameters.

If a patient or physician needs ongoing monitoring (critical case), the patient is admitted and sensors also gather essential information and feed it to the local server.

ii. Cloud Infrastructue

Cloud systems store, process and analyze large numbers of data collected through an IoT based system. Cloud services offer major services from anywhere and at any time including scalability, mobility and on-demand services. Cloud offers cloud software to show the patient data on demand to the doctors in a variety of ways and analyzes. Data privacy and security are two major problems that can be solved by approving, authenticating and alert messages.For each patient access control, a unique username is provided. Only after authentication of patients is a patient report / history exchanged among doctors. The massive cloud storage holds the history of the clinical records of patients, which is available by doctors remotely. Medicines, advice, appointments and follow-up for the patient are provided with message services.

iii. Optimized Analysis using Computational Intelligence

In this phase computational models are applied on the data to provide optimized analysis and predictions. The phase is divided into two sub phases, first phase organize the data in a standard format in accordance with the computational model for analysis and second phase for decision making based upon analysis. Phase 1 has seven steps as *Problem Identification* to formulate the problem objective, here in our case is to identify the skin disease, its impacts and effects. *Data understanding* to assess the typeof data required, for disease detection, its availability and format.Da*ta preparation* to access the required patient skin data, its cleaning and formatting as per requirements. *Data analysis* to analyze large volume of formatted skin data efficiently with data analytics software. *Validation* to verify the result outcomes against the system requirements. V*isualization* to propose different visuals of the results for further action. Decision support system is the second phase which is used to analyze the data to give meaningful inferences. Four different approaches of data analytics are,

Descriptive analysis to determine the skin disease based upon the computational model. *Diagnostic analysis* is performed to analyse and find the root cause of the disease and isolating the confusing information. *Predictive analysis* to predict the specific outcomes/ effects due to the disease. In this phase decision making algorithms are applied for outcome based future predictions. *Prescriptive analysis* provides recommendations **b**ased upon the disease and its specific outcomes. Preventive strategies can also be predicted by analyzing the effects of environmental parameters on skin disease.

iv. Fast Decision Making

Optimized analysis results into classification and prediction of skin disease based on the paients' data. The results are made available to a team of expert doctors to facilitate good patient care. Based upon the inferences, predictions and epertise knowledge of expert doctors best medications and recommendations can be suggested and disease is cured. One major part of analysis is to study the change in the skin diseases with the change in environmental factors like temperature.This is a continuous process that runs in parallel with the skin monitoring. Graphs, statistics and inferences are generated by comparing patients skin disease patterns and chang ing environmental parameters.

The inferences generated may help in preventing the skin diseases in future by providing a pre-alert based on climatic conditions.

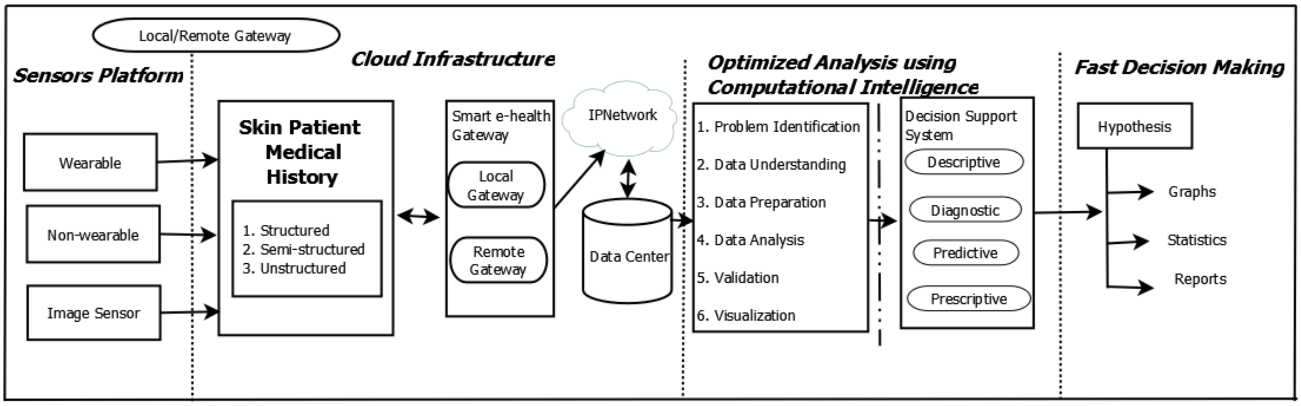

Fig. 3. IoT-based skin monitoring system architecture.

V. CASE STUDY

This section presents a case study to validate our IoT-based skin monitoring architecture. The study addresses the situation of a rural location where most of the people are suffering from a similar type of skin disease. The case study scenario is as follows:

We can implement the proposed IOT based skin monitoring system in remote areas where either the expert doctors are not available, or the patients are not able to visit the hospital due to some unavoidable reasons. The system may consist of a Van V_i equipped with m different skin monitoring sensors denoted by the set $S = \{S_1, S_2, \dots, S_m\}$. Let the Van V_1 moved to a remote location where patients $P = \{p_1, p_2, \dots . p_n\}$ are suffering from some common skin disease. Each patient will register through a mobile/desktop-based application, giving the primary details such as name, age, gender, location, mobile number, email etc. Then each patient p_j will get the registration number (login id) and password to access her account in application. Then the patient p_j will enter the details about her symptoms of disease and the problems regarding disease. Based on the primary symptoms of patient's p_j a set of required sensors $S_r^{p_i} \subseteq S$ for skin monitoring will be recommended by the system. The sensors will take the recommended readings and the images of the skin problems of the patients. A database $D = \{d_{p_1}, d_{p_2}, \dots ., d_{p_n}\}$ will be maintained for each patient p_i. This database is saved remotely on cloud and the team of expert doctors may access this database online or offline. For the purpose of security patients' consent is taken using mobile OTP for sharing his medical data among experts and doctors. Once the authentication process is over, the patient medical data can be processed and classified on cloud using secure algorithms and optimized models. The symptoms are compared with the existing database of disease in cloud for the purpose of classification and predictions. The Patients history and the prediction report are then accessed by the team of expert doctors for final diagnosis. Based upon the technically predicted results and doctors' diagnosis, medication is recommended. Based upon the improvements (severity) of skin disease level I, II or III, the assigned doctors can help to measure individual patient's recovery graph details. If the problem in skin seems worsening and patient need continuous physical monitoring, ambulance and hospitalization facilities are provided. Regular follow ups and monitoring process continuous till all the patients cure.

The module works in conjunction with a variety of environmental sensors in order to feel temperature, moisture, and pollution in the area of the disease. The sensors sensor environmental data, and the impact on the patients affected by skin diseases, can be analyzed. Inferences can be created and warnings can therefore be sent to patients for the prevention of skin diseases. It helps to protect the patient from potential skin conditions. When skin conditions are healed in this position, sensor-equipped van can be relocated to another specified spot.

VI. RESULT ANALYSIS AND DISCUSSIONS

Automation with the proposed system in the skin monitoring phase would result in reduced diagnostic time. Automation replaces manual work and is less vulnerable to human error. The system provides a consistent route to forecast performance. If the patient differs or there is an adverse drug effect, the situation can be immediately cured, not so quickly in the manual system. The treatment can take place at any point. Once data access and an on-demand therapy program are available, the average treatment time is therefore likely to decrease early recovery. Fig. 4 depicts the manual vs proposed system diagnosis days analysis. We observed that the diagnosis days is reduced upto 25% using the proposed system by doctor and patients. We have collected 35 skin diseased patients data including the days of the diagnosis by skin care consultant as shown in Table I. We have implemented proposed system and compared the result with the existing manual system. We found that the proposed system efficiency is better than the existing manual system. We found that reason that it was because of the medical history of the skin patient was accessible at data centres in real time for the doctor in order to identify skin diseases. The sensors capture real-time skin patient data or images and pass it to data centers via local or remote gates in real-time. The proposed computer model analyzes existing data, defines the problem and promotes decision-making method that decreases the diagnosis time. Automation systems gather more data in each cycle and increase performance and optimisation, making them more effective and accurate. Hence, the automated system reduced the diagnosis time and also prevents from further skin problems by generating prevention and precaution alerts.

Table I. Patient's details with days of diagnosis.

	Days of Diagnosis	
Patient's Id	***Manual Sysytem***	***Proposed System***
p1	20	15
p2	25	20
p3	20	16
p4	20	14
p5	22	16
p6	22	17
p7	23	18
p8	20	15
p9	18	15
p10	25	19
p11	30	25
p12	15	12
p13	25	20
p14	30	22
p15	22	14
p16	25	18
p17	22	18
p18	25	15
p19	30	24
p20	35	28
p21	25	19
p22	24	20
p23	26	20
p24	30	23
p25	20	15
p26	25	14
p27	25	15
p28	30	24
p29	15	10
p30	18	13
p31	30	26
p32	25	18
p33	23	22
p34	24	17
p35	17	14

The machine also saves skincare facilities at low cost and time. Follow-up and tracking scheduling reduces appointment numbers, transport costs, fees for each visit, long hours of waiting and other patient expenses. It is also economic for doctors since physical infrastructure is not required for each location, staff are limited and paper waste is not required.Let C_M be the cost of manual system and C_A is the cost of automated system such that,

$$C_M = C_d + C_t + C_{time} + C_{oth} \quad (1)$$

where, C_d= doctors fees on each visit(multiple visits)

C_t=transportation charges on each visit(long distance)

C_{time}= cost of visiting and waiting time(multiple)

C_{oth}=other expenses

$$\text{And, } C_A = C_a + C_r + C_{oth} \quad (2)$$

where,

C_a= charges of application download(one time)

C_r= registration fees(one time)

C_{oth}=other expenses

Here, if we compare C_A and C_M, we can clearly find that $C_A < C_M$ as no requirement of multiple times long distance visits and transportation cost. Also time which is very important factor is saved otherwise added to the cost.In our proposed system visiting and waiting time is reduced due to automation as patient data is fetched through sensors vans planted in nearby hospital. Also no longer waiting time as patient after providing her skin data can always go back and will receive the prescription and other details on his mobile.This shows the efficiency of proposed system architecture in terms of low cost and time saving.

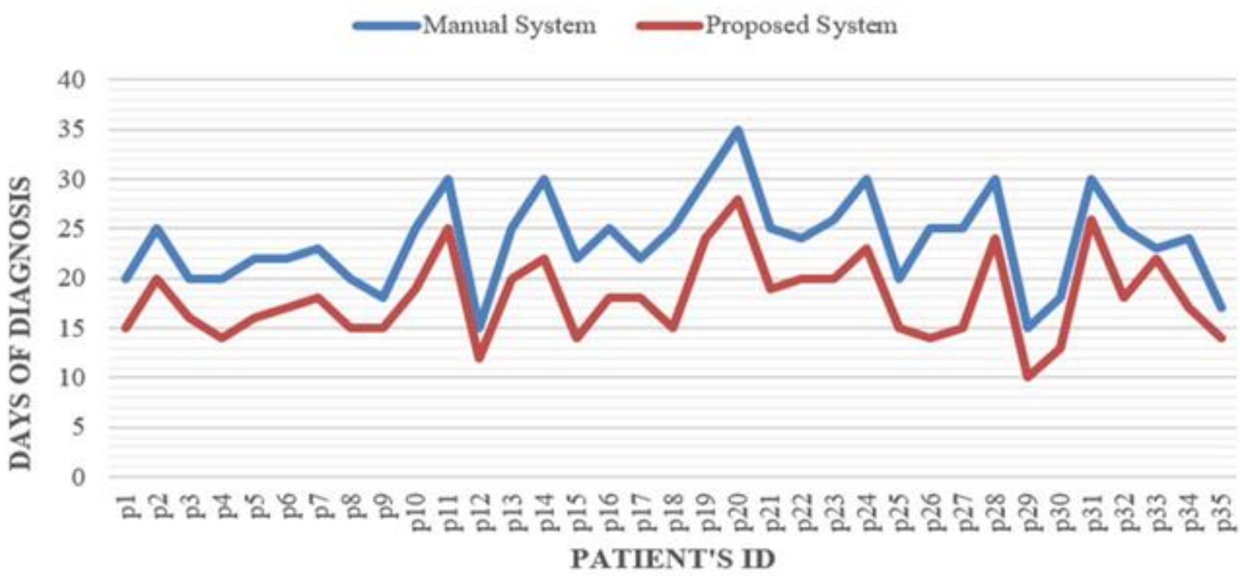

Fig. 4. Manual vs proposed system diagnosis days analysis.

The benefits of the proposed IoT-based skin monitoring systems are.

Patient:

- *Capable of getting expert physician care at home.*
- *Reporting and monitoring on a regular basis.*
- *Mobile prescribing and appointing applications.*
- *Climate change awareness and smartphone warning.*
- *Safe and authenticate treatment and control processes through the use of unique identity.*
- *Low cost and cost-effective*
- *Save time.*

Doctor:

- *Remote control from the site is possible, may help patients.*
- *The system can help physicians identify and predict diseases in diagnosis.*
- *Expert Groups will exchange and respond to medical data with the best medicines.*
- *Centralized and local drug storage offered in various cases and advice will help to identify skin problems in the future in an original and easy manner.*
- *Assists in the study of the effects on the skin disease of environmental parameters to provide for prevention measures before climate change.*
- *No necessary infrastructure and minimal workers, thus saving costs.*

Cosmetic Market:

- *Based on research trends and skin parameters change, appropriate cosmetic, moisturizers, cleansers etc. can be recommended and sold in that area*

VII. CONCLUSION AND FUTURE SCOPE

The paper focused on IoT-based skin surveillance system that offers diagnostics and surveillance of skin diseases in real time. In order to improve the diagnostics cycle and avoid skin diseases, we have suggested a methodology and framework for skin health supervision.

The proposed system tackled various challenges such as the increased cost of skin care, sharing of information and the lack of experts in skin care. It also merged patients and doctors with the latest technology to improve communication and better services. Potential skin diseases will also help prevent and cure the idea of the implementation of atmospheric sensors to research the effect of climate change on skin disease. The program helps the people, in particular those who have no or restricted skin care facilities in remote areas. In order to ensure real-time skin monitoring and analyzes, a greater emphasis on security and privacy can be introduced as part of a testing program.

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