

# Intelligent Health Care Monitoring System using IOT

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**Abstract** — Faults in medical industry can take one's life hence this model provides all time monitoring and accurate documentation, thereby helping to avoid flaws in medical industry. In the proposed system health accuracy is delivered by the method of mobile computing knowledge for refining by detecting abnormalities in patient parameters using sensors and the results have been stored in cloud system and when the pulse gets low, the patients profile and location will be automatically sent to doctor to provide fast treatment. The profile will consist of information about patient such as blood group, undergone surgery information, allergies etc.

**Keywords** — Rx receiver pin, TX- transmitter pin, Arduino, Sensors

## I. INTRODUCTION

The medicinal productions are converting to cloud based industry because medicine enlarges to medical event monitoring systems. It will produce report and the report will be sent to control system, through which the alert will be sent to doctors and patient Attender. Medical monitoring guidelines are becoming strong and accurate. There are some platforms which are used to observe the patient's health parameters using sensors such as Arduino, it's a tool to connect things with internet. We can connect sensor with internet using Arduino and thereby the system provide efficient monitoring and transmission of results. This proposed model uses cloud technology for storing and retrieving the data hence it provides high degree of scalability for storing and provides location independent services. Arduino provides Esp8266 cloud platform by which it can be connected with Wi-Fi. The proposed model helps to provide error free documentations and high scalability and it takes medical industry to next level of treatment.

There are many solutions that have a huge cost in addition remain not faultlessly combined through additional smooth home-based elucidations. The paper offers an ECG isolated observing method that stays committed to non-technical consumers in prerequisite of abiding strength checking in domestic situations and combined with Internet-of-Things (IoT) organization. The pattern comprises of a

wide-ranging perpendicular elucidation through sequences of benefits by esteem to the formal of the skill bearing in mind together the samples with incorporated façade close and ECG prototype sensors through record-low vitality for each actual quantity of quantized stages, smooth home-based structures complete a solo IoT structure. Antonovinciet. al. has proposed an achievement and organization of biomedical data using IoT. It suggestions the option of conducting health documents by means of several portable method. Records resolve related by the standard ethics and at what time an aberration is witnessed, the persistent is alerted.

The medical observing, memory development, health documents contact and statement through healthcare supplier in alternative positions using wearable's complete the SMS or GPRS using Body sensor network systems and identifies crisis condition. It monitors the biological indications starved of the requirement of intermission of the patient's standard existence and enlightening their existence value. Here is nope relative among the radars and the bedside apparatus payable to the wireless strategies and wireless systems.

It does not entail the persistent to be restricted to his cot and permit him to interchange everywhere then again encompasses existence inside a precise coldness on or after the bedside observer. In utmost cases, strength observing will be prepared by setup preoccupied by means of wireless systems such as profitable cellular/3G systems or wireless LANs. The analysis of the setup concerned with systems variations with phase or situation. Restrictions uninterrupted strength nursing is not probable and substitute indications might not be transferred starting a persistent to healthcare sources. Continuous strength nursing can be reached out to through exhausting ad hoc wireless systems that can transmit over a real-time transmission, vital signs. The healthiness documents beginning numerous patients can be conveyed wirelessly by means of multi-hop overwhelming pattern to a base-station in utmost organizations.

The cloud computing means loading and retrieving documents and databases above the internet in its place of processor's firm determination. The fog is just a representation designed for the Internet. It drives rear to the beings of

flowcharts and demonstrations that would exemplify the enormous server-farm structure of the internet as unknown but a distended, snowy cumulus cloud, accommodating associates and doling ready evidence as it glides. It stock documents proceeding or route drivers from the hard drive and it is called native loading and calculating. All the prerequisite is substantially nearby to you, which funds retrieving the facts is profligate and informal for that one processor or others on the native network. Operational off in the rigid enterprise is in what way the processor production operated for years. The cloud is also not about having committed system involved loading hardware or server in residence. Packing files on a household or workplace system does not tally as employing the cloud. It is measured cloud computing want to contact the documents or packages above the internet or at the exact minimum have that statistics synced with supplementary evidence above the network.

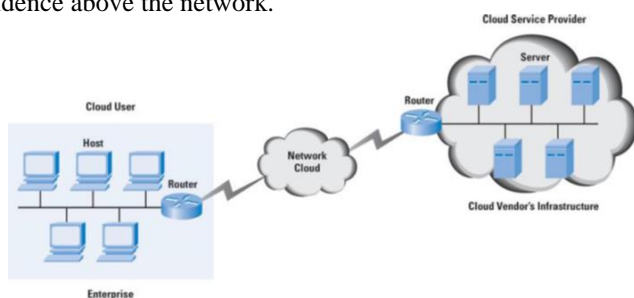


Fig.1. Cloud technology

## II. LITERATURE SURVEY

### A. MINING HUMAN ACTIVITY PATTERNS FROM SMART HOME BIG DATA FOR HEALTH CARE APPLICATIONS

The authors of this paper are Abdul Salam yassine, Atif alamri and Shailendra Singh. The paper describes about analyzing big data to provide social movement arrangements designed for healthiness attention solicitations. In this recommended system they consumption repeated arrangement quarrying, gathering exploration and extrapolation to quantity and examine drive norm deviations flickered by occupant's activities. The classification is capable to remove the design of application convention which is recycled as response to the bayesian system for immediate and enduring happenings extrapolation. The productivity of the organization is exploited by definite healthiness maintenance presentations provisional on the anticipated procedure. They provide numerous configuration quarrying for determining appliances-to-appliances suggestions, i.e., responsible which usages are initial organized, trailing the categorization of day-to-day accomplishments is decisive for remanding the persistent as soon as unusual performance is identified. Statistics agreed used in this learning is a gathering of smooth patterns documents beginning five firms. They develop imitation dataset designed for introductory estimation of the prototypical. Clustering analysis is done by K-Means incremental clustering analysis. Clustering is done by discovering appliance usage time with respect to period of the day, interval of the time and month of the year. And Bayesian network is used for activity prediction and all homes have

electricity it provides a cheapest way of observing changes in behavior but in case of Power off or shut down, monitoring is a challenging aspects

### B. SMART METER PROFILING FOR HEALTH APPLICATIONS

The authors are Carl Chalmers, Michael Mackey, William Hurst, and P. Fergus. Its abstract is about using the data classification technique to detect changes in behavior by energy usage in home. This proposed system would permit exhaustive, everywhere the regulator, observing of a individual's comfort and would be predominantly beneficial for tracing entities grief from self-limiting situations such as alzheimer's, clinical depression and parkinson's disease. The proposed scheme expenditures records arrangement performances to identify abnormalities in behavior concluded peculiar drive norm forms in the home. Outcomes illustration that it was potential to gain an inclusive exactness of 99.17% with 0.989 for compassion, 0.995 for specificity and an global fault of 0.008 when exhausting the VPC Neural Network classifier. It institutes a exhaustive relationship amongst dynamism norm and other dynamics such as explicit curative complications. It improves early revealing of difficulties and deteriorating disorders, for instance perturbing configurations accumulative in occurrence and interval. For the data processing it uses the data set of 13 trades were nominated for investigation, 9 with regular evaluations and 4 with unusual analyses. The explicit performances consist of: radial basis function neural network classifier(RBNC),back-propagation trained feed-forward neural network classifier (BPXNC), trainable linear perceptron classifier (PERLC), levenberg-marquardt trained feed-forward neural net classifier (LMNC), automatic neural network classifier(NEURC), voted perception classifier (VPC) and the random neural network classifier (RNNC). As long as more capable dynamism norm, development a liability easiness is the improvement but Power off will prime to difficult in observing.

### C. MEASURING USERS PRIVACY PAYOFF USING INTELLIGENT AGENTS

The authors are Abdulsalam yassine, sheervin shirmohammad and its abstract is about Intellectual cause created structure for determining confidentiality reckoning and intervention. It provides security for the isolated documents but the agent necessities to communicate with the external agent which may lead threat. The suggested design comprises of five categories of fundamental sections: 1) Facilitator mediator 2) Database mediator 3) Reputation mediator 4) Payoff mediator 5) Negotiation mediator. The statement prototype is built on asynchronous communication transient. The facilitator mediator has three main constituents which route simultaneously and communicate by replacing interior, i.e. intra agent, messages. The obtainable documents arrangement has three fascinating appearances in the perspective of outline documents subcategories that are associated to every supplementary: main, data in dissimilar classifications have altered context-dependent encumbrances. Since the assessment of the reserved data may diverge from individual perspective to alternative, its conformation might

S.NO	TITLE	AUTHOR	ABSTRACT	ADVANTAGE	DISADVANTAGE
1	Mining human activity patterns from smart home big data for health care applications	Abdul Salam yassine, Shailendra Singh and Atif alamri	Smart home big data are analyzed to provide mortal movement configurations for healthiness attention submissions	Since all homes have electricity it provides an cheapest way of observing changes in behaviour	In case of Power off or shut down, monitoring is an challenging aspects
2	Smart meter profiling for health applications	Carl Chalmers, Michael Mackey, William Hurst, P. Fergus	Using the data grouping technique to distinguish changes in behaviour by drive procedure in home	It provides more competent drive procedure, development and fault acceptance	Power off will lead to problem in monitoring.
3	Measuring users privacy payoff using intelligent agents	Abdulsalam yassine, sheervin shirmohammadi	Intelligent Agent-based framework for measuring privacy payoff and negotiation	It provides security for the private data	The agent needs to communicate with the external agent it will lead to a threat
4	Cloud-Supported cyber physical localization framework for patients monitoring	M. Shamim Hossain	Using smart phones to obtain voice and electroencephalogram signals	Results are stored in cloud hence it provides high scalability	Usage of GMM algorithm can fail to work if the dimensionality of the problem is too high

have dissimilar insinuations on the smooth of exposure. Second, the replacement amount of isolated documents in the identical separation is continuous and autonomous from the present equal of discovered facts, i.e. supposing that one of the isolated facts has stood exposed, skimpy the repose of the facts in the identical subcategory will not surge the revelation menace of confidentiality. A user's age material can be articulated by stage, year of birth or high school advancement day. Significant all of them at the same time permits only bordering enhancements. This will allow considering each reserved data subsection as one unit. Third, data in dissimilar subsections are not exchangeable illuminating any one of them will escalation the discretion risk.

#### D. CLOUD-SUPPORTED CYBER PHYSICAL LOCALIZATION FRAMEWORK FOR PATIENTS MONITORING

The authors are M. Shamim Hossain. Aim of this proposed system is, using smart phones to acquire voice and electroencephalogram signals. The patient's reaction to the convenient phone is bimodal. The patient expresses unremitting vowel /AH/ in façade of the convenient and it is documented as a wave file. While enunciating, the EEG signal is fixed determined a sensor dedicated to the exterior seeming of the spoken travelling of the enduring via a specifically intended chip. The symptom is then taken to the convenient by the bluetooth proficiency. For simulated determination, the voice data and the EEG signal are accomplished from the Saarbruecken Voice Database (SVD) manufacturing. The future technique practices GMM for exhibiting and organization. The idea of GMM is to exemplify the data as a probability density function (pdf) weighted by Gaussian functions. In the background, once the data is taken through the mobile phone, it is transmitted to the cloud server to

accumulation the indications and abstract structures. During preparation the suitable waiter also does the demonstrating and during challenging, it does the sorting using log likelihood ratio. The paper initially intensive on i) the recognition of three categories of signal, such as EEG, MFCC (voice), and MFCC+EEG and then ii) then investigating the amount of work of encrypting and coursing the data. First, the frame used only one modality, either voice or EEG signal. In case of voice, the types were MFCC ran a additional research using alternative ordinary voice feature. Its improvement is, consequences are stored in cloud hence it provides high scalability. Disadvantage of this paper is treatment of GMM algorithm can fail to work if the dimensionality of the problem is too high.

#### III. OBJECTIVE

To make available extreme suitability to the consumer or persevering throughout ECG measurements, particularly for a prolonged time of use remains to be the main aim and to improve a classification that measures body high temperature, blood pressure and heart rate. This setup is used for monitoring the patient activities. It is aimed at designing a system that has a database storage of patient date over a period of time and to analyses the duly collected data by using sensors.

#### IV. METHODOLOGY

ECG Signal appearances and Circuit necessities is an ECG device that comprises of a signal processing circuit and an Analog Front End (AFE) circuit. The ECG signal characteristics along with the ECG application are main factors that the AFE circuit proficiencies and necessities be governed by on. The electric prospective amendment manufactured on the body's surface by heart contraction is depicted in a graphical representation which can be

distinguished at dissimilar body localities and this is the task of an ECG. These devices have a number of leads depending on the application that is targeted and this can range from one to a maximum of 12. In order to monitor, generally a one-lead AFE is enough as temperatures of a macroscopic value are only necessary.

The ECG signal comprises of three leading constituents

- The authentic distinction ECG signal
- The discrepancy time-varying ECG offset
- The common-mode signal.

The computer-based off-line analysis or interpretation of data can be affected by the existence of baseline wander in the ECG signal. In argumentative states, the indication chain can be initiated to saturate too. A common-mode intermediation signal can be produced from coupling to the human body of electromagnetic interference produced by electrical systems, such as AC power lines, electronic devices, fluorescent lights, etc. It is frequently the largest noise or disturbance constituent (up to 1.5 V) and needs to be impassable because it can saturate the signal amplifier. This intervention must be taken into explanation only if the ECG sensor is strongly coupled to ground (even a battery-operated instrument can be coupled to ground by a large (~100 pF) chassis-ground parasitic capacitance). An instrumentation amplifier with high common mode rejection ratio (CMRR) is used in the AFE to reduce the common mode interference.

#### A. TEMPERATURE SENSOR

The measurement of body temperature is done by using the LM35 sensor by putting it in contact with body and sensing of the body temperature is done. It is calibrated linearly in Celsius. External calibration is not required and it has the capability of self-heating.

#### B. PULSE SENSOR

When a finger is placed on the sensor, it gives out an Analog output of the heartbeat: the usage behind the designing of a pulse sensor. For every heartbeat, the LED blinks and denotes the sensor's working. By connecting the output pin of the sensor to the controller, the output of the sensor is noted. The working principle of sensor is based on light modulation at each heart pulse by blood flow through the nerves.

### V. ARCHITECTURE

The specified sensor monitors the patient check attributes such as pulse, temperature and blood pressure and returns monitored data of the patient to the cloud control system through which doctor and one trusted entity of the patient can view patient data. Arduino is used to connect with ESP8266 which act as a cloud platform. A specific user ID and password is given to both patient and doctor, they can able to view the data but they cannot modify it.

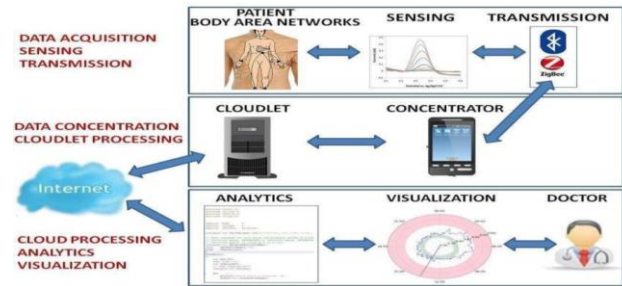


Fig.2. Architecture of patient monitoring system

#### A. DATA ACQUISITION SENSING TRANSMISSION

Data acquisition is the development of control group signals that quantify tangible domain physical environments and renovating the consequential illustrations into digital numeric tenets that can be employed by a processor. Data acquirement arrangements, shortened by the acronyms DAS or DAQ, classically convert analog waveforms into digital tenets for dispensation.

#### B. DATA CONCENTRATION CLOUDLET PROCESSING

The objective of cloudlet is to intensification the rejoinder time of submissions successively on mobile device by high-bandwidth wireless connectivity, overwhelming low latency and by hosting cloud multiplying source. Many portable amenities divided the solicitation into a front-end client sequencer and a back-end server database subsequent the traditional client-server model. The front-end mobile presentation offloads its functionality to the back-end servers for numerous details such as fast-moving up treating. With the initiation of cloud computing, the back-end attendant is classically introduced at the cloud datacenter.

#### C. CLOUD PROCESSING ANALYTICS VISUALIZATION

Photographic analytics is the science of investigative intellectual sustained by collaborating visual boundaries. Today, data is created at an unconceivable proportion and the facility to gather and accumulation the documents are aggregate at a quicker frequency than the capability to investigate it. Visual Analytics procedures consent pronouncement manufacturers to syndicate their human tractability, resourcefulness and circumstantial awareness with the massive loading and dispensation capabilities of today's computers to improvement discernment into multifaceted difficulties. Using forward-thinking visual boundaries, humans may straight relate with the data examination proficiencies of now processor, agreeing them to make well-informed conclusions in multifaceted conditions.

### VI. EXISTING SYSTEM

The specified existing system has no data accuracy and the information will be visible only to doctor in addition to that there is also a problem of location while accessing the reports. smart meters are used for monitoring but Power off will lead to problem in monitoring and doctor cannot know his condition and in addition to that no fast retrieval of data. Usage of GMM algorithm can fail to work if the dimensionality of the problem is too high. It provides security for the private data but the agent needs to communicate with the external agent which may lead to threat. Patient attender



cannot view the data. Marginal improvements will only be possible inspite of the knowledge. A single modality, either voice or EEG signal will be used by the framework.

## VII. PROPOSED SYSTEM

It provides accuracy in the storing and retrieving of data. Alarm will be sent to both patient attender and doctor so both can be notified when there is a critical health condition. As it is stored in cloud it provides location independent service and provides fast retrieval of data. GSM helps to keep track of location. Arduino is used to connect things with internet. It provides security while storing in cloud, a username and a password is given to doctor and patient. It doesn't use any smart meters for monitoring hence there will be a non-interrupt monitoring and in this case, the doctor and patient can view the data. It will not communicate with external agents, so there will be no threat in masquerade. As the data are stored in cloud it provides fault tolerance and high scalability. It provides a much reliable data transfer between cloud and sensor for which Arduino software is used.

## VIII. RESULTS AND IMPLEMENTATION

### A. INTERFACING TEMPERATURE SENSOR WITH ARDUINO

Temperature sensor is interfaced with Arduino through which it returns the temperature of the patient to cloud. Building a display for the temperature by using Arduino and sensor which constantly monitor temperature of patient. LM35 is a linear temperature sensor that is Analog and has an output voltage that varies linearly as temperature changes. The voltage productivity of the LM35 intensifications 10mv per degree Celsius in temperature. The sensor be functioned from a 5V quantity and position by existing is less than 60uA. Microcontroller do not accept Analog signals and thus signal conversion is essential and so the usage of ADC comes into play.

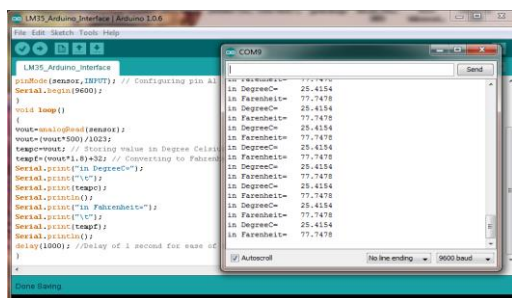


Fig.4. Output of Serial Monitor

### B. INTERFACING PULSE SENSOR WITH ARDUINO

To return the pulse of the patient, Pulse sensor is interfaced with Arduino. There are 3 pins. Namely, Ground pin, Vcc: 5V or 3V, AO: Analog Pin. In order to connect the Pulse sensor, the ground pins of both the pulse sensor and the Arduino is connected and the Vcc of pulse sensor to 5V of Arduino, both the AO's of the sensor and Arduino is connected. The LED is then connected to pin 13 and the ground of Arduino.

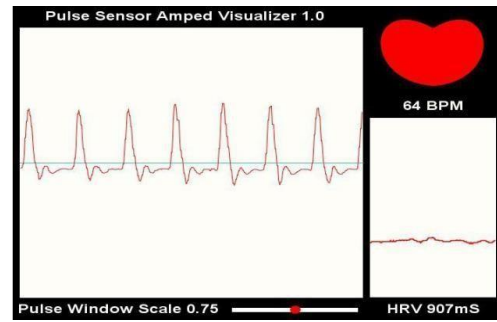


Fig.5. Generated output of pulse sensor

### C. INTERFACING WIFI MODULE WITH ARDUINO

The Wi-Fi module is interfaced with an Arduino through which we can connect to patient data to Cloud ESP8266. To send the patient data to cloud esp8266 device is placed to the Arduino, it's operated at 115200 baud rate of serial transmission. A default firmware that supports AT commands comes with ESP8266 and is connected by the RX and TX pins of the Arduino. A bare minimum sketch is uploaded and a check is done to notice if the pins are being used.

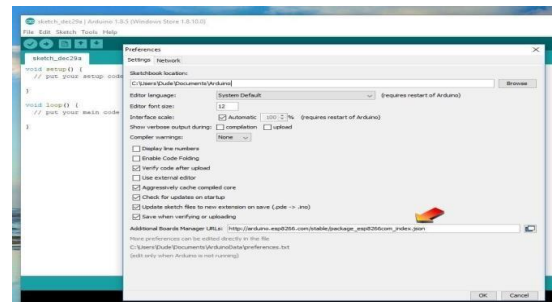


Fig.6. Arduino interface

## IX. RELATED WORKS

### A. INTERFACING TEMPERATURE SENSOR WITH ARDUINO

The specification of Temperature sensor is LM35. Temperature instrument is a thermocouple or a Resistance Temperature Detector (RTD) that collects the temperature from a exact foundation and changes the composed evidence into reasonable type for an gadget or an spectator. Temperature sensors are charity in numerous solicitations HV organizations and AC organization conservational controls, medicinal strategies and food dispensation units. The LM35 is one kind of temperature sensor that can be used to quantity heat with an electrical output reasonable to the temperature (in  $^{\circ}\text{C}$ ). It can quantity temperature more appropriately associate with a thermistor. This sensor produces a high output voltage than thermocouples and may not need that output voltage is enlarged. The scale factor is  $.01\text{V}/^{\circ}\text{C}$ . this sensor is used to distinguish detailed centigrade temperature. It procedures the heat. The sensor comes frequently in two form factors. One that comes in TO-92 package looks exactly like an ordinary transistor. Other one in a waterproof probe style which can be more valuable when you need to quantity something far missing, underwater or under the ground.

## B. INTERFACING PULSE SENSOR WITH ARDUINO

For Arduino, the Pulse device is a plug-and-play heart-rate instrument. It can be castoff by anyone who wishes to integrate conscious heart-rate data into their developments. The pulse sensor can be clipped on to the lobe of the ear or fingertip and once plugged into the Arduino and the heart rate can be analyzed.

## C. INTERFACING WIFI MODULE WITH ARDUINO

On a frequency of 900/1800 Mhz works the GSM/GPRS Modem-RS232. This has been assembled with a Dual Band GSM/GPRS engine – SIM900A and originates with an RS232 interface and thus permits a connection between a PC and a microcontroller with the RS232 chip (MAX232). Through AT command, the baud rate is configurable from 9600-115200. An internal TCP/IP stack containing GSM/GPRS Modem enables one to associate with the internet via GPRS. Data transfer solicitation in M2M interface, voice and SMS also finds suitability. A connection from the on nourishment Regulated Power quantity to unfettered power supply is facilitated. Calls and SMS can be done and accessing the internet is possible using this modem through simple AT.

## X. ADVANTAGES

Accurate and up-to-date data about patients is provided along with surround information helping to promote legible and complete documentation along with quick access to the records of the patients. The patient can get prescriptions using web interface without going to hospital.

## XI. CONCLUSION

Systems for medical monitoring are becoming essential day by day to mainly reduce the cost of usage and availability issues. Independent medical checks along with the accuracy needed for a prolonged period of health check is facilitated through this and support of independent health environment is provided.

## XII. REFERENCES

1. M.S. Hossain, "Cloud-supported cyber physical Localization framework for patients monitoring," IEEE Syst. J., vol. 11, no. 1, pp. 118–127, Mar. 2017.
2. J. Liao, L. Stankovic, and V. Stankovic, "Detecting household activity patterns from smart meter data," in Proc. Int. Conf. Intell. Environ. (IE), vol. 6, Jul. 2014, pp. 71–78.
3. A. Yassine, A. A. N. Shirehjini, and S. Shirmohammadi, "Smart meters big data: Game theoretic model for fair data saring in deregulated smart grids," IEEE Access, vol. 3, pp. 2743–2754, 2015.
4. A. Yassine and Shirmohammadi, "Measuring users' privacy payoff using intelligent agents," in Proc. IEEE Int. Conf. Comput. Intell. Meas. Syst. Appl., May 2009, pp. 169–174.
5. K. Jack and K. William, "The UK-DALE dataset, domestic appliance-level electricity demand and whole-house demand from five UK homes," Sci. Data, vol. 2, p. 150007, Sep. 2015.
6. J. Clement, J. Ploennigs, and K. Kabitzsch, "Detecting activities of daily living with smart meters," in Advance Technology and Societal Change. Heidelberg, Germany: Springer, 2014, pp. 143–160.
7. M. S. Hossain and G. Muhammad, "Cloud- assisted industrial Internet of Things (IIoT)— Enabled framework for health monitoring," Comput. Netw., vol. 101, pp. 192–202, Jun. 2016.
8. P. Pouladzadeh, P. Kuhad, S. V. B. Peddi A. Yassine, and S. Shirmoham-madi, "Mobile cloud based food calorie measurement," in Proc. IEEE Int. Conf. Multimedia Expo Workshops (ICMEW), Jul. 2014, pp. 1–6.
9. S. V. B. Peddi, P. Kuhad, A. Yassine, P. Pouladzadeh, S. Shirmohammadi, and A. A. N. Shirehjini, "An intelligent cloud based data processing broker for mobile e-health multimedia applications," Future Generat. Comput. Syst. J., vol. 66, pp. 71– 86, Jan. 2017.
10. J. Han, J. Pei, and M. Kamber, "Data mining: Concepts and techniques," in Classification: Advanced Methods, San Francisco, CA, USA: Morgan Kaufmann, 2011, ch. 9, pp. 243–278.
11. S. Singh and A. Yassine, "Mining energy consumption behavior patterns for households in smart grid," IEEE Trans. Emerg.
12. J. Han, J. Pei, Y. Yin, and R. Mao, "Mining frequent patterns without candidate generation: A frequent-pattern tree approach," Data Mining Knowl. Discovery, vol. 8, no. 1, pp. 53–87, 2004.
13. J. Pearl, Probabilistic Reasoning in Intelligent Systems: Networks of Plau-sible Inference. San Francisco, CA, USA: Morgan Kaufmann, 1988.
14. P. J. Rousseeuw, "Silhouettes: A graphical aid to the inter-pretation and validation of cluster analysis," J. Comput. Appl. Math., vol. 20, no. 1, pp. 53–65, 1987.
15. N. C. Truong, J. McInerney, L. Tran- Thanh, E. Costanza, and S. D. Ram-churn, "Forecasting multi-appliance usage for smart home energy man-agement," in Proc. 23rd Int. Joint Conf. Artif. Intell., 2013, pp. 2908–2914.
16. G. Gargiulo et al., "An ultra-high input impedance ECG amplifier for long-term monitoring of athletes," Med. Dev. Evid. Res., vol. 3, pp. 1–9, 2010.
17. L. Stingeni et al., "The role of acrylic acid impurity as a sensitizing component in electrocardiogram electrodes," Contact Dermatitis, vol. 88, no. 1, pp. 44–8, 2015.
18. M. S. Naidu and V. Kamaraju, High Voltage Engineering, 4th ed.; Publisher: New Delhi, India, pp. 107–108, 2009.
19. S. Fuhrhop, S. Lamparth, and S. Heuer, "A textile integrated long-term ECG monitor with capacitively coupled electrodes," IEEE Biomedical Circuits & Systems Conference, 2009, pp. 21–24.
20. G. Andreoni, et al., "Sensor validation for wearable monitoring system in ambulatory monitoring: Application to textile electrodes," 2013 7th international Conference on Pervasive Computing Technologies for Healthcare and Workshops (PervasiveHealth), 2013, pp. 169–175.
21. M. Weder et al., "Embroidered Electrode with Silver/Titanium Coating for Long-Term ECG Monitoring," Sensors, vol. 15, no. 1, pp. 1750–1759, 2015.
22. A. C. Myers, H. 1 Huang, and Y. Zhu, "Wearable silver nanowire dry electrodes for electrophysiological sensing," RSC Adv., vol. 5, no. 15, pp. 11627–11632, 2015.
23. H.-C. Jung et al., "CNT/PDMS Composite Flexible Dry Electrodes for Long-Term ECG Monitoring," IEEE Transactions on Biomedical Engineering, vol. 59, no. 5, pp. 1472–1479, 2012.
24. Y.-H. Chen et al., "Soft, Comfortable Polymer Dry Electrodes for high Quality ECG and EEG Recording," Proceedings of International Electronic Conference on Sensors and Applications, Feb. 2014.
25. K. C. Tseng et al., "Development of a Wearable Mobile Electrocardiogram Monitoring System by Using Novel Dry Foam Electrodes," IEEE Systems Journal, vol. 8, no. 3, pp. 900–906, 2014.
26. J. Lee, J. Heo et al., "Flexible Capacitive Electrodes for Minimizing Motion Artifacts in Ambulatory Electrocardiograms," Sensors, vol. 14, no. 8, pp. 14732–14743, Dec. 2014.
27. F. Lin, S. Yao, M. Mcknight, Y. Zhu, and A. Bozkurt, "Silver nanowire based wearable sensors for multimodal sensing," IEEE Topical Conference on Biomedical Wireless Technologies, Networks, and Sensing Systems (BioWireless), 2016, pp. 55–58.
28. P. Sarati Das and J.-Y. Park, "A flexible touch sensor based on conductive elastomer for biopotential monitoring applications," Biomedical Signal Processing and Control, vol. 33, pp. 72–82, Nov. 2017.
29. Y. Ye-Lin et al., "Wireless sensor node for non-invasive high precision electrocardiographic signal acquisition based on a multi-ring electrode," Measurement, vol. 97, pp. 195–202, 2017.
30. P. Salvo, R. Raedt, E. Carrette, D. Schaubroeck, J. Vanfleteren, and L. Cardon, "A 3D printed dry electrode for ECG/EEG recording," Sensors and Actuators A: Physical, vol. 174, pp. 96–102, 2012.