ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 4, April 2017

Application of Computer Vision for Patient Monitoring System-A Review

Shailesh V. Ugale, Bhushan U. Bawankar

Assistant Professor, Dept. of CSE., DMIETR, Sawangiwardha, RTMNU University, Nagpur, Maharashtra, India

Assistant Professor, Dept. of IT., YCCE, RTMNU University, Nagpur, Maharashtra, India

ABSTRACT: Patient Monitoring system has been one of the most important devices used in hospitals. It helps to provide a means for caregivers to regularly observe patients in multiple intensive care units from a single remote location. The system may provide an addition layer of care, which includes software tools that support analysis of patients' values, vital signs, trends etc. In addition, from clinical observations, without a proper monitoring system, abnormal activities in wards such as unbalanced walking, bed climbing, and irregular body posing can lead to serious consequences, for instance falling, pains or injuries. In any of these incidents occurring, the only information that the medical staffs may be able to access is the occurrence itself and possibly the degree of the incident. In this paper review of computer vision application for patient monitoring system is presented.

KEYWORDS: Patient monitoring system; degree of the incident;computer vision application; single remote location.

I. INTRODUCTION

Patient Monitoring system has been one of the most important devices used in hospitals. It helps to provide a means for caregivers to regularly observe patients in a multiple intensive care units from a single remote location. The system may provide an addition layer of care, which includes software tools that support analysis of patients' values, vital signs, trends etc. In addition, from clinical observations, without a proper monitoring system, abnormal activities in wards such as unbalanced walking, bed climbing, and irregular body posing can lead to serious consequences, for instance falling, pains or injuries. In any of these incidents occurring, the only information that the medical staffs may be able to access is the occurrence itself and possibly the degree of the incident.For decades, there have been many works proposed to monitor patients automatically. Rawlese and Crockett evaluated a monitoring system automatically monitoring and recording some vital measurements such as temperature, pulse rate and blood pressure. Ko et al. studied the usefulness of MEDiSN, a wireless sensor network (WSN) designed to monitor vital signs continuously. PhyoWai et al. use multimodal sensors to observe patient's context and activities around the bed such as sleeping postures and movement around the bed. Using surveillance cameras to monitor patient is till new in this field of application and need to be explored. For example, in , they have installed camera at intensive care units for observing agitation in the sedated patients. It is believed that it can provide other modes of information useful to the doctors and nurses and intelligent system with cameras allows computers to have 'vision'. Monitoring means to interpret incoming system data in order to recognize alarm conditions.

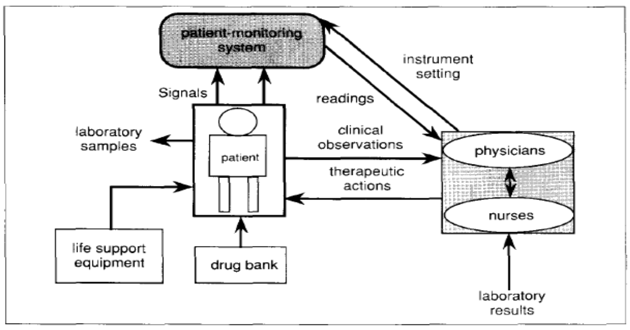

Fig 1. Patient monitoring and management environment elements.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 4, April 2017

Figure shows the elements of a critical care monitoring system, namely: patient, staff, therapeutic equipment, and monitoring equipment. In a typical intensive care unit, patient data is obtained from patient symptoms (pain, dizziness), clinical observations (auscultation, reflexes), patient history (previous chronic diseases, age), bedside instrumentation (ECG, BP, temperature) and laboratory tests (drug toxicity, enzyme analysis). The staff for interpretation and to take the most appropriate actions integrates all data sources. Therapeutic actions constitute a finite repertory composed mainly of drug administration, electrical (defibrillation) and mechanical (artificial ventilation) interventions, and manual actions (massage).

Four examples of situations requiring monitoring and management in medicine are briefly presented: 1) Temporary paralysis of the respiratory center of the brain; resulting in asphyxia and brain damage, 2) Renal damage; leading to poisoning by retention of urinary constituents, urea, and other nitrogenous metabolites, in the blood. 3) Surgical anesthesia; where powerful and potentially toxic drugs are necessary, thus modifying substantially the body's internal balance, and 4) Myocardial infarction; which could lead to circulatory failure provoking fatal arrhythmias. In order to monitor patients in these situations, four basic physiological conditions must be observed and controlled, with varied emphasis depending upon the case: 1) adequacy of ventilation, through following of breathing rate and blood gas analysis; 2) maintenance of nutritional levels, fluid balance, electrolyte balance, and acid-base balance; 3) determination of level of consciousness; and 4) circulatory system state, by continuous observation of the ECG, blood pressure and cardiac output .[1]

.

II. RELATED WORK

In [1] authors used describesAutomation on a general medical ward: Monitor system of patient monitoring. In [3]. Authors used an wireless sensing system in clinical environment and discuss and propose certain use to increase the efficiency ofthe patient monitoring process In [3] auther discuss aboutEvaluation and analysis of multimodal sensors for developing in and around the bed patient monitoring system there systematic evolution and various optionsIn [5] A computational approach to edge detectionauther give detail discusstion about how edge dection is taken out.In [6] auther pointed out different Method and means for recognizing complex patterns In [7] Performance evaluation of edge detection techniques for images in spatial domain

III. PATIENT MONITORING SYSTEM

Cameras of the patient monitoring system are installed in the patient wards with two different views, Bed View and Room View. For Bed View, it focuses on monitoring patient with specific conditions. In order to capture the activities of the patient take place on the bed, together with the nurses, we have considered 2 different angles, which the cameras can be mounted. The first way is to mount the camera on the ceiling above the patient bed. However, at this angle, the caregivers areconcerned on the patient's privacy. Taking into consideration of not intruding intopatient's privacy,we have decided to mount the camera outside the curtain rail of the patient bed. This gives both the patients and caregivers a choice to draw the curtain whenever they want. Figure 2a is a sample of Bed View image. For Room View, the purpose is to monitor the activities happen in the common area. Figure 2c and Figure 2d are sample of Room View images. Bed view is chosen because information found on the bed can help medical staffs to have a better understanding in patient conditions. Most of the patients on this bed is in crucial medical conditions where intensive care and attention are needed at all time. Traditionally, nurses have to routinely record patient information such as temperature, pulse rate, blood pressure, and vital signs. With the additional camera-based techniques, they help to monitor patient 24/7 and provide other modes of information, for example bed occupancy and extubation, which can lessen the workload of the nurses. Though the details of each patient are important, some general information from the room view is non-trivial. Apart from activities around their own beds, patients also have activities on the ward corridors. Room view will help provide these data such as accidents and activities inside or outside the wards.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 4, April 2017

(a) Bed View (b) Manual marked area of the patient bed (c) Room View (d) Room View

Fig. 2: *Samples of Bed View and Room View concerned.*

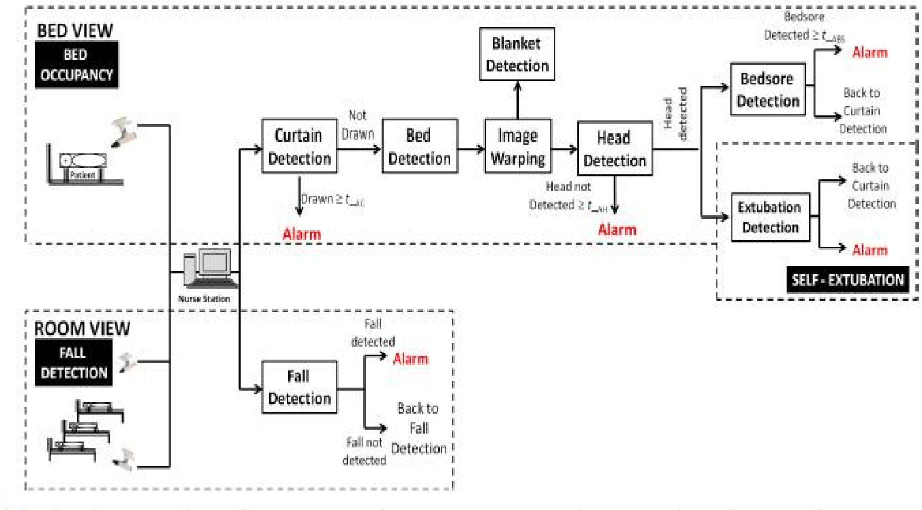

Fig 3. Overview of the Patient Monitoring System for the Bed View and Room View.

There are many interesting information spreading over the captured images for extraction. We have scoped down to three major issues which are linked to the safety and risk management of patients in the wards: Bed Occupancy (Bed View), Self- Extubation (Bed View) and Fall Detection (Room View).This section describes how the technologies are applied to extract the focused information. Fig. 3 shows the overview of the Patient Monitoring System.[2]

A. Bed Occupancy

Bed occupancy can be interpreted for various purposes such as studying the routine of patient, detecting the presence and absence of patient, and monitoring movement of patient on the bed. All these information are very useful to the nurses. For example, an absence of patient on bed for a period of time might suggest that the patient has encountered an accident such as fall in the toilet. Thus, with this system, it will alert the nurses on duty that the patient is absent for a period of time. Moreover, the system can act as a reminder to the nurse. If a patient is detected to be presence on the bed for more than a period of time, patient might have bedsore. Hence nurse can attend to the patient who is in need. For this part, it focuses on extracting and recording information from the capture frames: Curtain drawn, Bed Detection, Head Detection, Blanket coverage and Bedsore Detection. Fig 3 shows the overview of the Bed Occupancy.

*1)*Curtain Detection: *Cameras of the monitoring system*are installed in the patient wards. Due to the privacy issue, the cameras are mounted outside the curtain rail for each bed. This gives both the patients and caregivers a choice to draw the curtain whenever they want. Computer vision technology is applied here to estimate the percentage of curtain

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 4, April 2017

coverage on the image. The colour of the curtain with its variance is usedto estimate the area of curtain. Whenever the curtain covers more than 60% of image, it is considered drawn and closed.

I. Bed Detection: Once the curtain is detected un-drawn, itis important to first determine the location of the patient bed. Initially, we do manual marking at the area of the bed in our Vision-based monitoring system. Figure 2b shows an example of a manually marked area of the patient bed. However we have found that the location of the patient bed changes over time. This could be due to many reasons, one of the reasons the bed has shifted could be when the doctors are doing regular check-up or nurses are performing their cleaning duties on the patient. Also, it would be time consuming for the caregivers to constantly check and update the system the location of the bed. Thus bed detection is activated to locate the position of the bed. The proposed method is based on Canny Edge detectorand Hough Transformation. Fig 4 shows the process of our bed detection algorithms. This method is feasible in detecting bed shows in the Bed View images.[5]

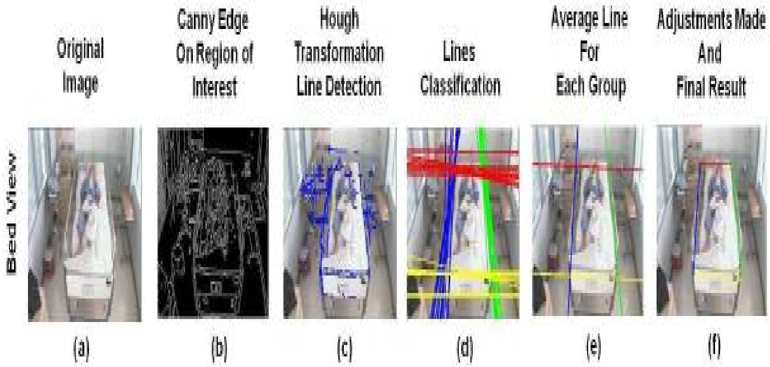

Fig 4 .overview of the bed detection.

1) Edge Detection: Canny Edge detector is used for edge detection on the original input image. The advantage of using Canny Edge detector is it has better edge detection performance especially noisyconditions.

2) Hough Transformation: After the edges are detected, next we use Classical Houg Transformation to locate the straight lines.

3) Classification of Lines: After locating the straight lines using Hough Transformation, we classify these detected straight lines into 4 different groups, Upper Horizontal Lines (UHL), LowerHorizontal Lines (LHL), RightVertical Lines (RVL), and Left Vertical Lines (LVL). We group these lines base on 2 factors, the midpoint of the line, (xm; ym), and the angle of the gradient line,

.

4) *Extension of Lines:* After classifying the lines, the nextstep will be extension of each line in the 4 groups. To illustrate this, the two coordinates for lines in UHL and LHL should be (1; y1) and (Iw; y2), and RVL and LVL should be (x1; 1) and (x2; Ih), where y1 and y2 2 [1; Ih], x1 and x2 2 [1; Iw], Ih is the image height and Iw is the image width.

5) Average Lines: So after the extension of the lines is tofind the average line for each group. Finding the average midpoint and average angle of gradient can do this.

6) Adjustment of Average Lines: The next stage will be adjusting the average line of each group. Two adjustments are made, the angle of gradient and the midpoint. First we have to computer the search space for the angle of gradient and the midpoints for each average line. 'Tuning' the average line of each group does this.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering
(An ISO 3297: 2007 Certified Organization)
Website: www.ijircce.com
Vol. 5, Issue 4, April 2017

7) Adjustment of the UHL: For the bed view, the head ofthe patient will not be always inside the bed boundary, we have to correct boundary such that the head will beinside the boundary. This is an important step as after bed detection, we can check the presence of a patient by using the skin color of the head. We need to check only the adjusted line for the UHL. To check if the head is inside the bed boundary, we find the intensity of the pixel falls on the upper horizontal line. If the standard deviation of the intensity is more than a threshold, then we conclude head is not inside the bed boundary. Weshall move the horizontal line upwards such that the standard deviation of the intensity is less than threshold [5]

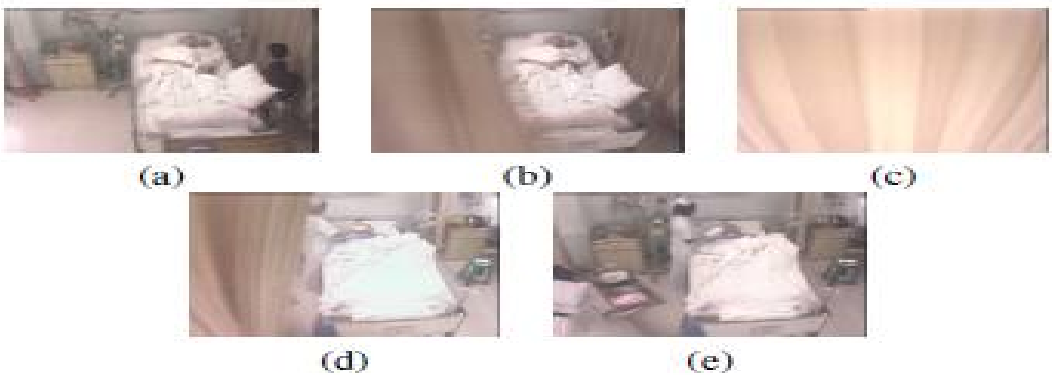

Fig 5 a Curtain is not drawn yet. b: Nurse is drawing the curtain: c: Curtain is drawn. d: Nurse is un-drawing the curtain. e: Bed is shifted after nurses perform cleaning duties.

Bed detection algorithm is implemented in the patient monitoring system. However, we do not apply bed detection for every frame as there is not much changes in the patient's bed position from frame to frame. In addition, bed detection is de-activated once the curtain is drawn. Usually, doctors and nurses will draw the curtain when they do regular checkup or perform cleaning duties. We realize the bed is usually shifted after these. Thus it is important to activate the bed detection once the curtain is un-drawn. Figure 4 shows some of the image sequences before and after the curtain is drawn. With these, we decided to apply bed detection algorithm in the following conditions:
1) Bed detection is done for every 10 minutes. However, we shall only update the bed position every hour. Averaging the positions collected every 10 minutes does this.

2) Bed detection is done if the curtain is detected to bedrawn at the previous frame. This is because the position of the bed is likely to change.

3) Image Warping: After knowing the locating the bed, we will perform a warping process before proceed into Head Detection. Image warping is done by changing the shape of the bed detected from a irregular quadrilateral to the size of the input image. Figure 5 shows an example of image warping done on the patient bed area. The purpose of doing this is to ensure the shape of the bed will not affect the detection, as the detection are mainly concentrated on the bed area

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 4, April 2017

Fig 6. Bed detection is done on the input image, a) the bed marking indicates the bed detection result. b): Image warping is done.

4) Head Detection: Once the position of the bed is located and pass through the warping process, head detection is activated to check if there is a patient on the bed. The approach begins by pre-defining the pillow area (the upper quarter of the detected bed area). Then head detection is applied to learn if there is a patient inside. Here we segment the area of skin-color. When the amount of skin-colour pixels in the area is more than the threshold, the head is considered detected.

5) Blanket Coverage: We observed this value because this could help in reassuring the bed occupancy status. Once the bed is found occupied, the blanket coverage estimated will be processed. The technique is based on the estimation of the bed area containing the colour of blanket. With this recorded value, we can know how room temperature could cause problems to patients.

6) Bedsore Detection: When the patient stays in a single decubitus position for a long period of time, bedsore is likely to occur. Moreover, the likelihood of bedsore occurring in the intensive unit care units patient is much higher, with 8% to 40% developing bedsores. However, constantly turning or moving the patient and support the patient by pillows in order to provide maximum comfort can prevent bedsore. Thus, with this system, if the patient is detected to be presence and yet not moving for a period of time, the system will then prompt the nurses on duty. We approach this by using frame difference to detect any body movement find on the patient bed.

B. Self-Extubation

Self-extubation is widely known that it can cause risks forincreased morbidity and mortality and it has been observedthat it occurs around 1.15 times per 100 intubated days,approximately once in 3 months of intubation in paediatric intensive care unit. Therefore it is worth to have an alert fora quick response when a self-extubation is detected. Herewe observe the motion on the bed through computer visionusing frame difference with connected component analysis.Additionally, we have designed a new uniform for patient towear for enhancing the system performance. Red, green andyellow cloths were stitched to the right arm, left arm and neckarea respectively on the original patient uniform as shown inFigure 11a. When there is a big movement of the arm towardsthe neck area, it will trigger a soft alert to call for quickattention from the nurses.

C. Fall Detection

Falls are common among patients and cause serious consequences. Success in detecting fall can provide immediate attentions and treatments to the injuries which can reduce the level ofseriousness in the consequences. It is important to define fall as there are many arbitrary meanings to this term.According to the nurses in the collaborating hospital, they have defined fall as an unexpected or uncontrollable changeof body position from slipping or dropping to the ground which will possible cause injury. In addition, the nurses have classified falls into 9 different types These 9 types are falls due to environment factors, near fall, fall without injury, fall with small injury, fall with injury like Hematoma or muscles tear, fall causes temporary disability, fall causes permanent disability, fall causes serious injury, and fall causes death.Amount these 9 types of fall, we will focus on 1 type of fallsin this project, fall happens due to

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 4, April 2017

environment factor (suchas poor lighting). In, computer vision algorithm is applied to detect fall. The technique extract foreground silhouette and then estimate the 3D position of body parts through body part tracking and detection and 2D-to-3D Projection Geometry. It shows that it is sufficient to be implemented in practical and be useful.

D. Alarm

In order to alert the caregivers on duty, alarm system is installed in the patient monitoring system. Alarm is undoubtedly useful as it allows the nurses to give a fast response to the situations. We have installed alarms at 6 different detections, Curtain Detection, Head Detection, Blank Detection, Bedsore Detection, Extubation Detection and Fall Detection. We have 3 different levels of alarm, the Green, the Yellow and the Red. The Green level shows the environment is safe, the Yelloalarm indicates attention is needed from the caregivers, and the Red alarm indicates the alert persists more than a period of time.

1) Curtain Alarm: A Yellow level alarm will be given once the curtain is detected to be drawn. This is to inform caregivers on duty stating that the monitoring system is inactivated or camera cannot detect patient. However, if the curtain is drawn for more than a period of time, tAC, the system will then send a Red level alert signal to the nurse station.

2) Occupancy Alarm: When a patient is not detected for the first 2 minutes, we will send a Yellow level alarm to the caregivers. However, if the head is not detected for more than a period of time, tAH, the system will then send a Red level alert signal to the nurse station. The absence of the patient might suggest that the patient has encountered an accident such as a fall in the toilet or corridor.

3) Blanket Alarm: When the blanket coverage falls less than a threshold, a Yellow level alert will be sent to the caregivers to call for attention. However, if the blanket coverage persists to fall below the threshold for a period of time, then a Red level alert will be activated.

4) Bedsore Alarm: Similar to blanket coverage, if the patient is detected to be presence and yet not moving for a period of time, tABS, the system will then prompt the nurses on duty by sending a Yellow level alarm. However, if the patient is not attended to after the Yellow level alarm is set off, and then the Red level alarm will be triggered.

5) Self Extubation Alarm: No Red level alarm is given for self-extubation detection, this is because our technology is not ready. Thus a Yellow level alarm is given when there is a big movement of the arms towards the neck area.

6) Fall Detection Alarm: A Yellow level alarm is sent to the caregivers once a patient is detected to be in a bending position or lying still for a few minutes at those indicated dangerous place However, once a fall detected or patient continues to lay still, a Red alarm is triggered

III. EXAMPLES OF PATIENT MONITORING SYSTEMS

In this section, we provide a description of the most representative examples of well-known system architectures for health monitoring, including both research and commercial solutions, enlisted in a chronological order of their appearance. for health monitoring applications.

CodeBlue intended for emergency medical care. It is designed to operate both with a small number of devices under almost static conditions, such as hospitals, as well as in ad-hoc deployments at a mass casualty site. CodeBlue utilizes a set of medical sensors integrated with some commercial-off-the-shelf platforms (i.e., Mica2, MicaZ, and Telos motes). The sensing units measure the vital signs and transmit their data directly to APs, attached is a low-power wireless infrastructure, on walls. Physicians subscribe to the network by multicasting. This system architecture is very scalable with self-organising capabilities. Literature related to this monitoring system recognizes the need of data security and privacy protection and suggests the use of ECC approach for the key generation and TinySec for symmetric encryption. However, none of the suggested approaches have never been implemented within the system. CodeBlue

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 4, April 2017

supports scalability, timeliness and security, but it fails in terms of reliability. The results indicate that packet delivery ratio drops drastically in a (*i*) multi-hop network and (*ii*) with high sampling measurements.

The **AID-N** health monitoring architecture is designed in three layers. Layer 1 consists of an ad-hoc network for collecting vital signs and running lightweight algorithms, able to operate on a limited memory and computing capabilities. Layer 2 includes servers that are connected to the Internet toward information to a central server, located in Layer 3.The intermediate servers are laptops and PDAs that send thedata. Intra- and beyond-WBAN communications is supportedvia IEEE 802.15.4 and IEEE 802.11, respectively, while aflexible security level is provided (i.e., from low to high level).AID-N is a real-time system architecture that fails in terms of reliability in LPWNs with unreliable links and also in networks with high sampling measurements.

The **CareNet** system architecture builds a heterogeneous network infrastructure and provides a two-tier wirelessnetwork for data sensing, collection, transmission, and processing. The intra-WBAN communication uses IEEE 802.15.4 wireless standard to send the data from Telos motes, while a multi-hop IEEE 802.11 wireless network provides a high performance backbone structure for packet routing. This architecture comes with a scalable software platform and built-in security communication mechanisms, which enable a reliable and privacy-preserving data transmission within the system. CareNet supports intra- and beyond-WBAN communications with a reasonable reliability, scalability and security. However, CareNet neglects the real-time issue in critical health monitoringapplications

.

The **MobiHealth** system is designed for ambulantpatient monitoring that employs cellular network (i.e., UMTSand GPRS). The patient is provided with a number of sensors, measuring the vital signs and communicating with a mobile base unit (collects the data) via Bluetooth and ZigBee. Thus this architecture supports both intra- and beyond-WBAN communication, however, mechanisms for security are not provided. MobiHealth provides reliability and inter-operability issues, while it fails in terms of security and data privacy.

MEDiSN is a wireless sensor network used to automatethe process of patient monitoring in hospitals and at disaster scenes, developed in a collaboration of John Hopkins UniversityHospital, University of Latvia, University of Maryland Medical Center and Aid Networks. The system consist of a number of a mobile sensor-based physiological monitors that collect the medical data of a patient, temporarily store the data and transmit it to the nearest relay points. Relay points are

Self-organised into bidirectional routing tree and they transmit the patient's medical data to gateways. In the final phase, the data is stored within the back-end databases and is available to authorised personnel only. Security protection includes encryption for each physiological monitor and authentication and user authorisation. However, the details regarding the implemented security mechanism have not been revealed in the existing literature.

LAURA is a wireless sensor based lightweight system for monitoring of patients within nursing institutions. Architecturally, the system consist of (i) a localization and tracking engine to locate patients based on the samples of the received signal, (ii) a personal monitoring module that classifies the movements of the patients eventually detectinghazardous situations, and (iii) a wireless communication infrastructure to deliver the information remotely. The benefit of the approach is its ability to be quickly deployed, due to adopted self-calibration method. Authors address the need of security and privacy preserving mechanisms, however they omit to provide any details on the existing implementations.

IV. CONCLUSION

In this paper, the ongoing research within patient monitoring systems is reviewed. Patient monitoring system intends to provide an addition layer of care, which includes tools that help in detecting falls or risky moments, happens in the wards, recording and monitoring the activities of a patient on the bed. Privacy issues are one of the concerns from the doctors and nurses. However, after discussions with the patients and their relatives, they concern more of safety than privacy issue. In addition, this would provide nurses easy views of the wards from the nurse station. The preliminary

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 4, April 2017

performance of the system gives us a lift that bed occupancy assumption works well in real data though bedsore, self-extubation and fall detection are not easy to test because of small chances of accidents.

REFERENCES

[1] J. M. Rawless and G. Crockett, "Automation on a general medical ward: Monitron system of patient monitoring," British Medical Journal, vol. 3,pp. 707–711, Sept. 1969.
[2] J. Ko, T. Gao, R. Rothman, and A. Terzis, "Wireless sensing systems in clinical environments: Improving the effciency of the patient monitoring process," Engineering in Medicine and Biology Magazine, IEEE, vol. 29, pp. 103–109, Apr. 2010.
[3] P. W. A. Aung, F. Foo, H. Weimin, B. Jit, J. Phua, L. Koujuch, and H. Chi-Chun, "Evaluation and analysis of multimodal sensors for developing in and around the bed patient monitoring system," Engineering in Medicine and Biology Society (EMBC), 2010 Annual InternationalConference of the IEEE, pp. 2159–2162, Sept. 2010.
[4] J. G. Chasea, F. Agogueb, C. Starfingera, Z. Lama, G. M. Shawc,A. D. Rudgea, and H. Sirisena, "Quantifying agitation in sedated icu patients using digital imaging," Computer Methods and Programs in Biomedicine, vol. 76, pp. 131 – 141, Nov. 2004.
[5] J. Canny, "A computational approach to edge detection," IEEE Trans.Pattern Anal. Mach. Intell., vol. 8, June 1986.
[6] P. Hough, "Method and means for recognizing complex patterns," 1962.
[7] M. Juneja and P. S. Sandhu, "Performance evaluation of edge detection techniques for images in spatial domain," International Journal of Computer Theory and Engineering, vol. 1, no. 5, pp. 614 – 621, 2009.
[8] J. C. PhD, D. R. B. MD, and E. A. A. PhD, "Pressure ulcers in america: prevalence, incidence, and implications for the future. an executive summary of the national pressure ulcer advisory panel monograph,"Advances in Skin and Wound Care: The Journal for Prevention and Healing, vol. 14, pp. 208–215, Aug. 2001.
[9] J. A. Balon, "Common factors of spontaneous self-extubation in a criticalcare setting," International Journal of Trauma and Nursing, vol. 7, pp. 93–99, July 2001.
[10] P. Kittipanya-ngam, X. G. Yu, and H. L. Eng, "Computer vision technologies for monitoring system in tele-physiotherapy," ACM Proceedings of the 3rd International Convention on Rehabilitation Engineering and Assistive Technology, pp. 188–195, Apr. 2009.
[11] S. Ullah, M. Mohaisen, and M. A. Alnuem, "A review of ieee 802.15.6 mac, phy, and security specifications," Hindawi International Journalof Distributed Sensor Networks, 2013.
[12] Y. Hovakeemian, K. Naik, and A. Nayak, "A survey on dependability in body area networks," in 5th International Symposium on Medical Information Communication Technology (ISMICT), March 2011.
[13] W. Elghazel, J. Bahi, C. Guyeux, M. Hakem, K. Medjaher, and N. Zerhouni, "Dependability of wireless sensor networks for industrial prognostics and health management," Computers in Industry, 2015.

BIOGRAPHY

Shailesh Ugale is a Assistant Professor, Dept. of CSE., Datta Meghe institute engineering Technology and Research Sawangiwardha, RTMNU Nagpur University. He received Master of Technology (M-Tech) degree from RTMNU, Nagpur University, MS, India.

Bhushan U. Bawankar is aAssistant Professor, Dept. OfIT, Yashvantrao chavan collage of engineering, Nagpur, RTMNU Nagpur University. He received Master of Technology (M-Tech) degree from RTMNU, Nagpur University, MS, India.