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An IoT Based Remote HealthCare Monitoring System through Emotion Recognition

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Abstract

There are an increased number of patients and elderly people who are alone worldwide. These people are often treated in –home and at times enter into a critical situation that may require help. The facial expressions are widely researched and employed to classify people emotional states. Such facial expressions have already been studied to determine the emotional health of an individual which, in turn, can be used as an important symptom for the diagnosis of various dis-eases such as: schizophrenia, depression, autism, bipolar disorder. Capturing facial expressions over a certain period of time can give an idea of to what extent the patient is feeling pain and can enable nurse/family members to decide the feelings of the patient and to provide necessary assistance. This research work describes the design of a system for continuous monitoring of patients/elderly people through person identification and emotion recognition to provide healthcare in home environments in an automatic way through an IoT infrastructure without human intervention. Using smart camera the patient's images are captured continuously and transmitted to the decision maker (laptop/desktop) for person identification. Once the patient is identified, he/she is monitored continuously for emotion recognition through facial expressions and the detected emotions are stored in the cloud. When abnormal condition is detected, an alert message is sent to the care taker/nurse.

Keywords- E-health, Remote Monitoring, Person Identification, Emotion Recognition, Internet of Things

I. INTRODUCTION

Tele-care is the continuous, automatic and remote monitoring of real time emergencies and lifestyle changes over time in order to manage the risks associated with independent living. Devices range from those where the user presses a button that raises an alert at a control centre, such as a pendant alarm or medical alert/personal emergency response service (UK and US terminology respectively), to systems that monitor the person's well-being, environment, or both, and which trigger - without, if necessary, the person's conscious involvement - a warning that the well-being has deteriorated or that an untoward event has occurred. There is a rapidly growing interest in using mobile phone (cell phone) technology to enable such monitoring to take place outside the home.

Some systems give the person immediate feedback so that memory problems in particular can be accommodated and the person. It is the term for offering remote care of elderly and physically less able people, providing the care and reassurance needed to allow them to remain living in their own homes. The use of sensors may be part of a package which can provide support for people with illnesses such as dementia, or people at risk of falling. It mitigates harm by reacting to untoward events and raising a help response quickly. Such as safety confirmation and lifestyle monitoring have a preventive function in that deterioration in the Tele-care. User's wellbeing can be spotted at an early stage.

In its simplest form, it can refer to a fixed or mobile telephone with a connection to a monitoring centre through which the user can raise an alarm. Technologically more advanced systems use sensors, whereby a range of potential risks can be monitored. These may include falls, as well as environmental changes in the

home such as floods, fire and gas leaks. Carers of people with dementia may be alerted if the person leaves the house or other defined area. When a sensor is activated it sends a radio signal to a central unit in the user's home, which then automatically calls a 24-hour monitoring centre where trained operators can take appropriate action, whether it be contacting a local key holder, doctor or the emergency services. It also comprises standalone which does not send signals to a response centre but supports carers through providing local (in-house) alerts in a person's home to let the carer know when a person requires attention.

It is important to note that it is not just a warning system if someone strays from home but is also preventative measure whereby people are brought back and kept in the community through regular communication. There are now a large range of services available with some of the most known being the pendant alarm, mobile care phone system, pill dispenser, telephone prompt service the movement monitoring, fall

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detector and more. Multi-lingual services have now been introduced opening the service up to a wider audience. All play a role in maintaining people's independence and allowing people to stay in their own homes.

Many people who live alone, or who are alone for long periods, choose to have an alarm system so that they can summon assistance should they require it. These systems, once known as community alarms, are now generally referred to as Tele-care and have been developed to offer a range of options and choices. There is a large choice of systems available, ranging from simple pendants which trigger a pager in another part of a home to pendants which dial, via a telephone line, directly to a 24-hour monitoring station, and even systems which will alert someone if you do not move around your home as you normally would.

- Tele-care technologies are not intended to replace the care taker
- They help to reduce stress and worry
- Greater peace of mind
- Greater personal freedom knowing the person being cared for is being monitored
- Provides support and reassurance when care taker is sleeping, or not on the premises
- Rapid response in an emergency
- Helps to reduce cost of care since a care taker does not always need to be present
- Can help to monitor a person's movements, routines and daily patterns informing family or care taker when to best have a human presence while at other times assistive technology monitoring will suffice
- Monitoring can be a measure of a person's decline, or improvement and wellbeing
- 'Key Safe' avoids costly repairs and speed of entry if the emergency services need to gain access

II. Current Studies on Remote Health Care

This section examines the advances made in based on IoT technologies with a view to describing and explaining the main challenges of this research study. The authors of [6] review the emerging concept of Health "Smart Home" and picture potential applications of these systems, such as social alarm systems and re- mote monitoring. The paper also discusses prominent technologies that are being deployed and reports pilot projects of e-care systems already in use by hospitals and residences.

The advances of in home healthcare [7] are also due to the application of Ambient Intelligence (AmI) [5] and Artificial Intelligence (AI) [3, 4]. The combination of modern sensing equipment, with advanced data processing techniques and wireless networks culminates in the creation of digital environments that improves the daily life of residents. Most of the studies [8] in the literature focus on the use of body sensors and specific devices when providing assistance to elderly people with special needs. The main concern in this case is the privacy of the other residents. A few studies [2] use cameras for improving the analysis of the environment (e.g. detecting possible hazardous situations) while providing a system that is non- intrusive. The two different approaches (sensor-based and camera- based) clearly have advantages and disadvantages and should be used with specific objectives.

This work argues that the use of a camera-based approach enables the emotional state of the patients to be analyzed and can provide a non-intrusive system that is not heavily dependent on attached Sensors, unlike most of the current solutions. The proposed solution introduces new features for treating patients in home environment based on their emotions.

The goal of the system is to ensure safety and provide services to users through monitoring techniques. The system is based on image processing and can provide solutions that are integrated with other control devices. In this case, a sensor based on image processing has a combination of filters, frame rate comparisons and other algorithms that act intelligently in the environment. This enables the detection of movements and patterns of the activities of a resident, such as speed and direction. It should be noted, how- ever, that no attempt is made to analyze the emotional state of the residents in order to assess the state of their health.

The authors of [2] set out a solution for assisting elderly and vulnerable people to reduce or mitigate accidents experienced during the night. The system is based on night vision and operates through a minimum of interactions with the patients. It is algorithmically based on the notion of causality and spatiotemporal reasoning and the system alerts and provides explanations to care- givers about past accidents or accidents that may occur. The results of the system (alerts and explanations) are based on a set of causal rules that refer to the places and times of activities, leading to a likely scenario within the house.

Related literature detailed below. We provide the following comparison items to ensure that an over- all view is given:

1. Continuous monitoring of patient's healthcare in the home Environment.
2. Privacy is ensured.
3. Critical situations (falling sick, depression) can be easily intimated to care taker via SMS.

To the best of our knowledge, none of the proposals in the literature take into account the patient's emotional side and hence they fail to exploit a considerable amount of "rich" information available in facial expressions in health care. This includes detecting pains and other emotional related issues.

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III. Overview of Proposed System

IoT Based Remote healthcare monitoring system through Emotion Recognition

In the proposed approach the images of the person are captured continuously by the smart camera. These images are captured continuously and they are sent to the decision maker for further processing using SVM and PCA algorithms. The image processed is then compared with the profile of the patient and if the person is identified as a patient, the monitoring starts else the monitoring is ignored. Once the patient is recognized, the monitoring of the patient starts and the images of the patient are captured continuously for emotion recognition through facial expressions. Based on the facial expressions, the emotions of the patients are classified using classifiers.

Capturing facial expressions over a certain period of time can give an idea of to what extent the patient is feeling pain and can enable a nurse/relative to decide whether help is required or not (fig.1).So that the patient will get the instant help from the care taker/nurse.

In our proposed system Laptop is used as decision maker which is connected via internet /Bluetooth with the smart camera fixed in the patient room. Once the video is captured continuously it is send to the laptop where the further processing will be done. Finally the detected emotion will be sent to the cloud and stored

(Free cloud example Drop box, Google Drive) and alert message will be sent to the caretaker. The role of decision maker is to make decisions about the emotions of the patient which include surprise, happiness, sadness, disgust, anger and fear based on the images captured by camera. Based on the results of decision maker, the recognized emotion of the patient will be sent to the care taker through a SMS immediately.

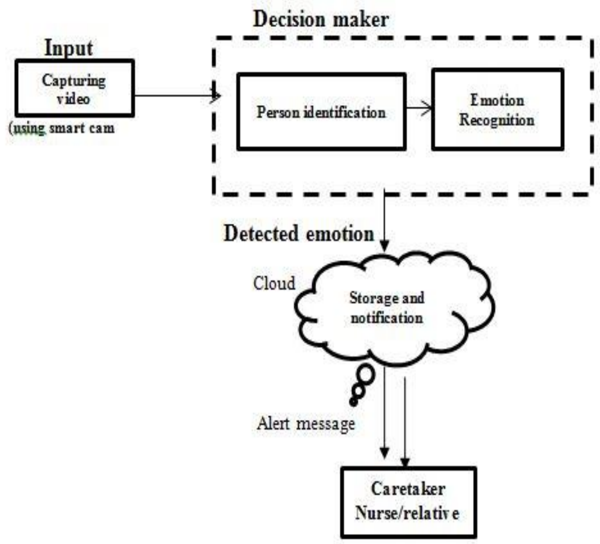

Fig.1 Overall system architecture

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Our system has three stages.

- **Person Identification.**
- **Emotion Recognition.**
- **Storage and notification**

A. Person identification:

In the person identification module, video is taken as input once the images are pre-processed, the component **PCA classifier** independently identifies the facial components and extracts the features using the maximum continuous outputs of the component classifiers with in rectangular search regions around the expected positions of the components were used as inputs to the geometrical configuration classifier.

The values obtained are then mapped with the value of images in the database through pattern matching. If the values match, then the person is identified as a patient and the monitoring process. It plays a important role in privacy issues and efficiency of the system not to waste the time for monitoring other than patients.

Principal component analysis (PCA) has been called one of the most valuable results from applied linear algebra. PCA is used abundantly in all forms of analysis - from neuroscience to computer graphics because it is a simple, non-parametric method of extracting relevant information from confusing data sets. With minimal additional effort PCA provides a roadmap for how to reduce a complex data set to a lower dimension to reveal the sometimes hidden, simplified dynamics that often underlie it.The problem of multi-dimensional data is its visualization, which would make it quite tough to follow our example principal component analysis (at least visually). We could also choose a 2-dimensional sample data set for the following examples, but since the goal of the PCA in an “Dimensionality Reduction” application is to drop at least one of the dimensions, I find it more intuitive and visually appealing to start with a 3-dimensional dataset that we reduce to an 2-dimensional dataset by dropping 1 dimension.

$$\boldsymbol{\mu_1} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \quad \boldsymbol{\mu_2} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} \quad \text{(sample means)}$$

$$\boldsymbol{\Sigma_1} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad \boldsymbol{\Sigma_2} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad \text{(covariance matrices)}$$

Alternatively, instead of calculating the scatter matrix, we could also calculate the covariance matrix using the in-built numpy.cov () function. The equations for the covariance matrix and scatter matrix are very similar; the only difference is that we use the scaling factor for the covariance matrix. Thus the Eigen spaces will be identical (identical eigenvectors, only the eigenvalues are scaled differently by a constant factor).

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$$\Sigma_i = \begin{bmatrix} \sigma_{11}^2 & \sigma_{12}^2 & \sigma_{13}^2 \\ \sigma_{21}^2 & \sigma_{22}^2 & \sigma_{23}^2 \\ \sigma_{31}^2 & \sigma_{32}^2 & \sigma_{33}^2 \end{bmatrix}$$

In the proposed system PCA plays a vital role in Patient Identification to identify the patient. Based on Euclidean distance minimum value is compared with threshold value. This solution is based on an important property of eigenvector decomposition. Once again, the data set is X, an m x n matrix, where m is the number of measurement types and n is the number of data trials.it includes the following steps

1. Normalizing the images
2. Forming the covariance matrix.
3. Sort and eliminating those whose Eigen value is zero.
4. Normalizing the Eigen vectors.
5. Finally showing the Eigen faces.
6. Finding Euclidean distance (fig.2).

Person identification is very much required in our system since some other persons (such as family members, nurse etc.,) may visit the patient's room for providing food, medicine etc., and the monitoring of those people should be ignored in order to protect their privacy. The existing CCTV monitoring system performs only the monitoring operation and no other processes are performed. But our proposed system performs monitoring operation as well as person identification, emotion recognition and sending message to the caretaker. Our system can be evaluated using the parameters **Accuracy** and **Precision.** For the captured videos the confusion matrix is framed using true positive, false negative, false positive and true negative values which are a special kind of contingency table with two dimensions ("actual" and "predicted") and identical set of values in both dimensions.

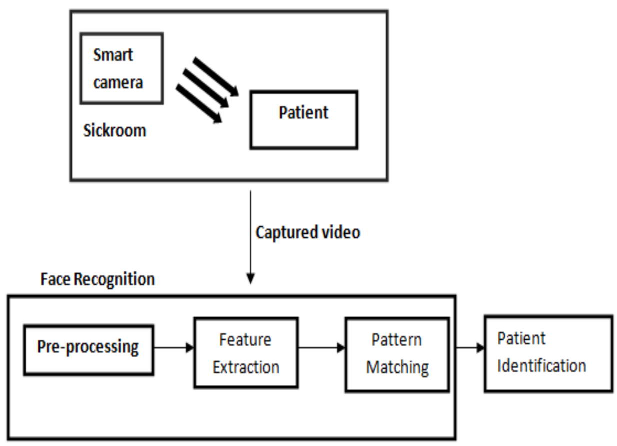

Fig.2 Flow diagram of person identification

B. Emotion recognition:

Once the patient is identified, the emotion recognition process takes place. In this module, the frames extracted in the person identification module are used to find the emotion. The additional RGB components in the frames are converted into gray. The features are then extracted from the frames using the Spatial – Temporal feature extraction algorithm. The facial features such as eyes, nose and mouth are identified for the input frame. Optical flow estimation is used to characterize and quantify the motion of the feature points in the video stream. By estimating optical flow between video frames, the velocities/variations of feature points in the video can be measured. After the estimation of Optical flow, the **Support Vector Machine (SVM) classifier** is used. In this algorithm, the images in the training set are sorted and labeled with indexes. The difference between the classification error formation and the sparse error formation is calculated. Based upon this distance, the class matching the input data is predicted. Emotion recognition plays a important in so many applications Like Medicine, E-learning, Monitoring etc. In our proposed system SVM classifier is used to classify the emotions. It is a supervised learning model that analyzes data used for classification and regression analysis. Given a set of training examples, each marked for belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall on. In addition to performing linear classification, SVMs can efficiently perform a non-linear classification using what is called the kernel trick, implicitly mapping their inputs into high-dimensional feature spaces. When data are not labeled supervised learning is not possible, and an unsupervised learning approach is required, which attempts to find natural clustering of the data to groups, and then map new data to these formed groups. The clustering algorithm which provides an improvement to the support vector machines is called **support vector clustering** and is often used in industrial applications either when data is not labeled or when only some data is labeled as a preprocessing for a classification pass. The emotion recognition task is based on the psychological and cognitive science literature where it is stated that there are two basic views on the representation of emotions: categorical and continuous. In the categorical representation, different emotions are mapped into distinct categories. The most well-known example of this description is the set of six basic emotions, and the facial expressions related to them, which are innate and culturally uniform. All other emotional categories are then built up from combinations of these basic emotions. This approach is supported by the cross- cultural studies, which claim that humans perceive certain basic emotions conveyed by facial expressions in the same way, regardless of culture.The main advantage of a representation of categories is that people use this categorical scheme to describe observed emotional displays in daily life. The labeling scheme based on these categories is very intuitive and thus matches people's experience. Within the discrete models, the most widespread example is proposed in which lists the following basic emotions - happiness, sadness, fear, anger, disgust and surprise - as enabling humans to adapt to different everyday situations (fig.3).

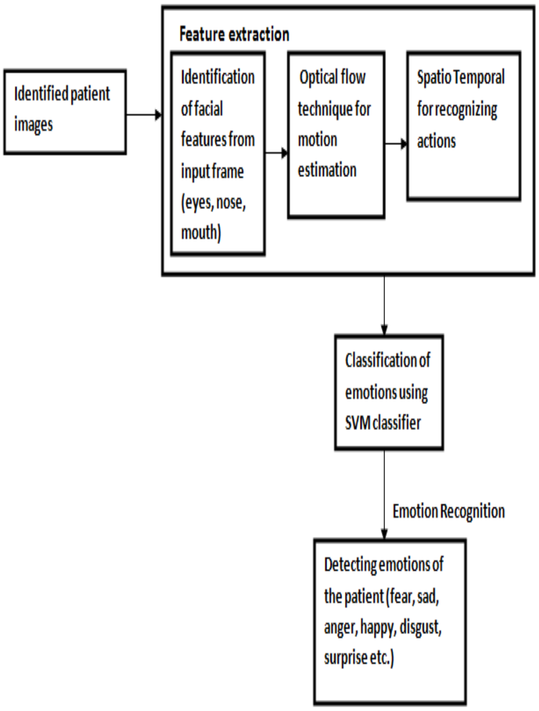

Fig.3 Flow diagram for Emotion Recognition

On the basis of the findings of this study and our view that the disgust emotion is not of value to our practical approach, we decided not to include its recognition in the proposed system to make it easier to identify other emotions. This in turn, can help in the development of a real time application since the AI algorithms will more readily identify the emotions in question.

C. Storage and cloud:

Once the emotions are classified, these emotions are stored in the cloud continuously which contains the patient details such as patient id, name, type of disease, caretaker name and mobile number and the emotional values of the patient. Cloud is a permanent storage where the patient details are preserved safely and it is also accessible by the authenticated caretaker/Hospital.

The stored emotions are then monitored in order to give an alert message to the care taker For example, if the detected emotion is anger, disgust, fear or sad and if the emotion is said to persist for a long time then the condition of the patient is assumed to be critical. During these situations, an **alert SMS** is sent to the caretaker/Family member (fig.4).

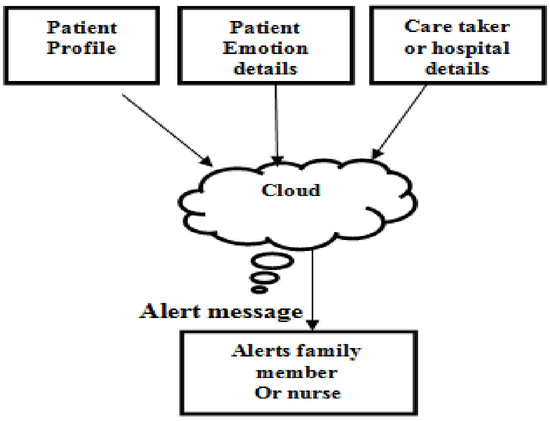

Fig 4. Flow diagram of storage and notification

IV. Conclusion

According to psychologists, emotions play an important role for recognizing the feelings of a patient which is used to monitor patients and elderly people that have special needs and also can enable a nurse/relative to decide whether help is required or not. We designed this system to help the elderly people/patients who are alone in the home and to provide assistance through continuous monitoring using IoT.

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