Innovative Monitoring System for TeleICU Patients Using Video Processing and Deep Learning

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Abstract—The Patients in Critical condition need intense monitoring and care. With ICU an Intensive Care unit we can provide this type of care to the patient. But nowadays shortage of Intensivist and Critical Care nurses is the major problem faced by the hospitals. To overcome such problems TeleICU (remotely handled ICU) centers are currently available. With the help of TeleICU control center, one can monitor the patients in Critical Care unit and can assist the person or doctor available at the physical location. TeleICU can provide round the clock monitoring. The person who is monitoring the patient from TeleICU control center should be proactive in monitoring. Another issue is one person can only able to monitor one patient at a time. So, this research aims to develop the system which overcomes the issues in current TeleICU system. For reducing the workload of the person in the control center and to automate some of the humans handled task we need the machine based interface which will take the decisions automatically and can able to collaborate with the existing system. The proposed system in this paper is developed for such TeleICU systems. The system presented in this research is able to identify the type of persons available in the ICU room with that it can automatically detect the several unusual activities done by the patient. As soon as any unusual activity is detected system will take real time decision and will notify the same to control center based on the type of activity and persons available in the ICU Room. To develop this system video processing and deep learning networks are used.

Index Terms—innovative monitoring system, TeleICU monitoring, deep learning, real time patient monitoring.

1 Introduction

Deep learning systems becoming more and more powerful in recognition of various things. There are so many types of neural network available for doing different type recognition or detection. Very popular deep neural network for object or person detection from the scene is Convolutional Neural Network. At present different type of architectures are available for Convolutional Neural Network(CNN) also. Some examples of CNN are recognition and detection of a person, detection any type of object, detection of several types of cancer disease etc. So, why can't we use the same for real time patient monitoring system?

Collabration of Video Processing and Deep Learning network will open the door for real-time object detection. Real-time object detection from video frame is not an easy task to do especially when the objects are moving and a background of frames is also changing. This problem was overcome by neural network architectures like FR-CNN(Faster Region Based CNN) [1] and YOLONet [2]. This both networks use the different type of division approach for multiple object detection from the single scene our detection algorithm is highly inspired by this two neural network. For detecting a type of person in the frame, a simple neural network can help but it will not work properly when the person is covered by some objects or when we have two or more types of person available in the same frame. This failure is not acceptable when we are dealing with the real-time patient monitoring.

TeleICU systems [3] are available for real-time patient monitoring. This system is developed for such location where hospitals have the shortage of intensivist. So, this system controls the whole ICU from the remote location. This system has control center at a remote location which is equipped with all necessary things to monitor the ICU patient. The physical ICU room contains the high-resolution camera which will send the stream of video to the remote control center. Now with the help of all equipment and monitoring screen, one person constantly monitor the patient and can connect to available Intensivist when any help is required.

Video processing is the essential part of the proposed system. As we monitor the patients in real time, video processing is required. The TeleICU room has the camera mounted on the top which will send the input as a stream to the system now time window is set and for that time frame the further processing is done. We faced various challenges regarding the processing of videos and data collection for experimental evaluation of system e.g. too many moving objects are available in particular scene or frame which makes patient motion detection task tough, various action done by the patients differs from patient to patient which is challenging task at time of detection.

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Real time patient monitoring through the computer system is bit challenging task because, we have to consider so many things to avoid the problems which will cause the bad result to the patient. i.e. the system should be so accurate and time bound. In next section, we will discuss the currently available systems and the different systems which we used for development of the proposed system.

2 Related Work

To make our system work properly we used various approaches from various work done. In this section, we are explaining how and what we used to develop our system as well as the system which is proposed previously. The main focus of our proposed system is the development of the person type detection system and motion detection system for the patient in ICU. For this, we refer the systems like F-RCNN(Faster Region Based CNN) [1], YOLONet(You Only Look Once) [2], motion detection based on ROI(Region of Interest) etc.

2.1 F-RCNN

Faster - RCNN is an approach for real-time object detection using the region proposal networks. RPN(Region Proposal Network) is a fully convolutional network which predicts the bounding box and objects score for all object in the image at the real- time. In their proposed system they combined the RPN with previous RCNN(Region Based CNN) to make it faster at evaluation time. They use the 5 shareable convolution layers and VGG-16 model for object detection in RPN. For generating regions they used the ın x n spatial window.

2.2 YOLO

You only Look Once 9000[2] is another model for detecting the multiple objects in real time. The current version of the model can able to detect 9000 different categories of the objects. With the help of batch normalization, high-resolution classifiers, convolution with anchor boxes, dimension cluster, and direct location prediction Yolo can able to detect the objects faster, better and with less localization error. YOLO is 10x faster than FRNN object detection approach. They use WordTree to combine data from various image sources.

2.3 Motion Detection models

In [4] they proposed the new approach for multiple object detection from the video frames using geodesic active contours. In their paper, they show that geodesic active contours can be used for tracking of objects. They use five-step approach to detect the object accurately. 1) sequence of input 2) transformation of video into images 3) moving object detection 4) tracking by geodesic contours 5) video reconstruction.

In [5] they proposed the new algorithm for tracking of one or more moving objects in the video. They use the 3 stage approach for motion detection 1) preprocess of video frames 2) Detection of objects 3) Tracking of objects. They are simply using novel background subtraction algorithm for detecting the multiple objects from the foreground.

2.4 ICU care systems

In [6] authors proposed the GUI-based system for monitoring of elder patient in the ICU. They create a Human-Computer interaction system for this task. They use the MS Kinect for gesture recognition of the patient after recognizing the gestures they will provide this information to the specified person. They provide the GUI for simple usage and their system work on natural hand interaction.

In [3] authors explain the TeleICU system. TeleICU system is an efficient and cost-effective approach for remote management of critical care. TeleICU is developed for overcoming the shortage of Intensivist. It has multiple names across the vendors.

3 Dataset Collection and Generation

Dataset collection and generations for the proposed system is challenging one. We need the real time data for ICU patients which are hard to find. So, we take the videos various videos related to ICU from the YouTube. This video contains many unwanted things like description and frames for the name of makers etc. So, we used below kind of approach displayed in the Fig.1

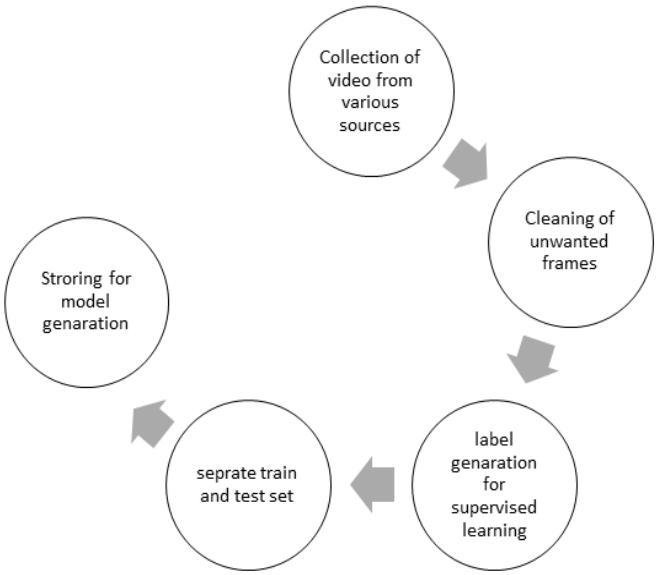


Fig. 1. Data Generation Flow

As depicted in the figure first we get the videos from the various sources after that we clean the unwanted frames and separates each frame from the video for labeled data generation than we create the train and test for modeling purpose. We apply this cycle first on one video only after that we used the result of that cycle for other videos i.e. we use the recursive approach for the labeled data generation

Here we use normal approach for train and test split of images. Train set contains the images with single class objects only whereas test set contains the images with multiple class onjects in same image. Current we created the reach train set with over 100,000 images in total for all classes.

4 Proposed System

This section describe the proposed system in detail. proposed system has various components as depicted in the Fig.2. Each component of the system plays the unique role in system to achieve high accuracy and time bound result.

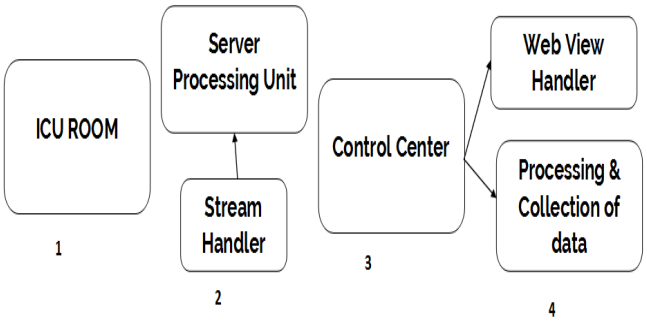


Fig. 2. System Componets

First component is the actual ICU Room where all action will occure. Second component is the server processing unit which do processing of video coming to it as a stream from stream handler. Third component is the control center of the TeleICU with which we collabrate for web event handling and notification. Fourth component is also use for processing and storing of data for further use.

4.1 Archtecture

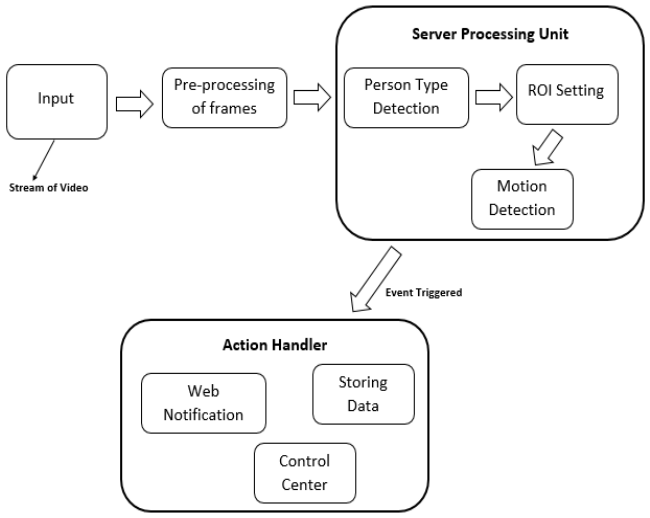


Fig. 3. System Componets

Fig.3 depicts the architecture of the proposed system. As displyed in the figure it mainly contains the three part Input, Server Processing Unit, and Action Handler. Input part handle the modules related to stream of video. Server processing unit handle all the part related to detection. Action handler part handle the action in the system after some detection occurs.

4.1.1 Input

Input is stream of videos comes to system from high resolution camera mounted in the ICU Room.

4.1.2 Server Processing Unit

Server Processing unit is responsible for various type of detection task. It handles the Person Type Detection and Motion Detection. For person type detection we use the CNN network but here proble is at time testing we have images with multiple class objects available in same image so it is bit difficult to predict all task. So, we use the novel approach for the detection of the all class in the image. We divide the whole image in various slice and apply prediction on each slice seprately with this we are able to detect the type person as well as location of the persion also. as displayed in the Fig.4 yellow squares are the window size(32 x 32) for 256 x 144 image size and we move image 16 pixel(green squares) for new slice. and red line is the result after the prediction

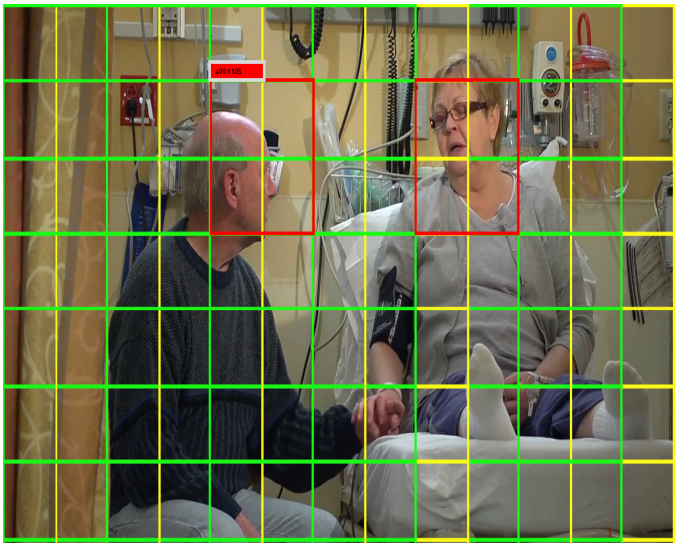


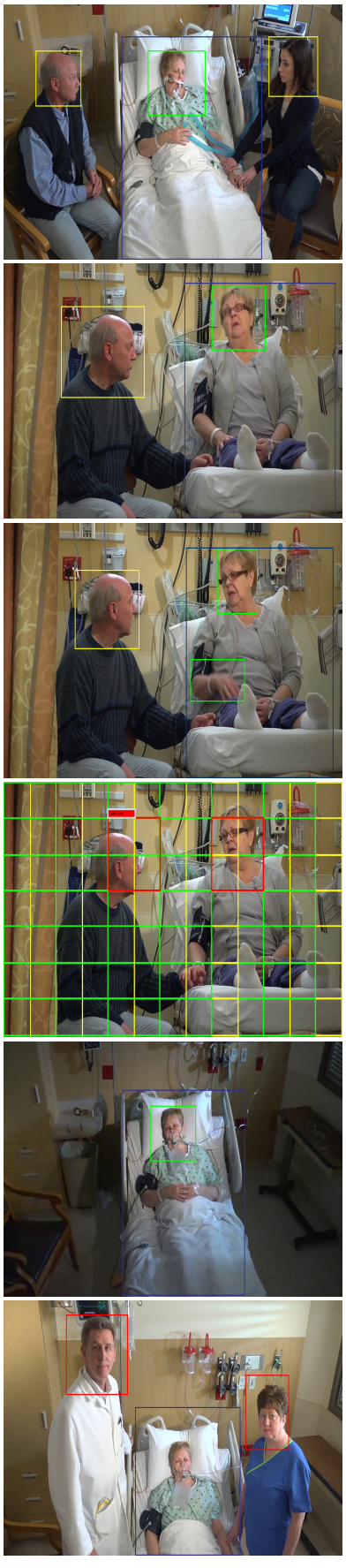
Fig. 4. Data Generation Flow

4.1.3 Action Handler

Action Handler Part handle all type action occures in the system. If any type of movement is done by patient we set the thresold for 3 and half second if it occurs for more than that we trigger the storing of all frames and than this many frames are send to motion detection module. Now based on the motion detected again the notification is genarated and send to control center of the TeleICU

5 Results

Results genareted by the system is depicted in below figures. We achieve mean AP of 89.3% for the person type detection algorithm our neural net currently sometimes fails for detection of relatives and nurse.



(a) (b) (c) (d) (e) (f)

Fig. 5. Results

6 Conclusion

The project is detecting the type of person and motion of person and integrating it to the event handler which will notify on the screen of control center. The project will be expanded to the type of motions that patient will be making and segregating according to the motions and alarming intensivist according to the severity.

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