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An Vision Based Monitoring System for Accurate Vojta-Therapy

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ABSTRACT: Vojta therapy is one type of physiotherapy to cure the patient having disorder in physical movementswhich can be encountered as either cerebral palsy or peripheral paralysis.This therapy is proposed by Dr.V Vojta , hence the name is vojta therapy.He had studied various patients with disorder in nervous as well as musculoskeletal system .He analyzed them and concluded that therapy must be reflective locomotive type which requires selective stimulation to over affected body part ,so that patient may carry out reflexive pattern by its own.The repetition of this stimulation in the long run brings the previously blocked connections most of the spinal and mind, and after a few sessions, child can carry out those actions without any external stimulation.In this paper we proposed an automatic monitoring system to track infants ,it can detect infant ,segment he/her ,extract features and classify them for further treatment.Here we used motion RGB pictures statistics and to extract baby from every frame region based segmentation algorithm is used.Wherefor feature extraction HOG descriptor & for classification purpose support vector machine(SVM) is used.The proposed algorithm has been perform over number of video datasets ,which we have collected from KIBS Baby Care Center ,Indore.Result of this algorithm shows that the proposed method is very simple, accurate and economical for home based therapy.

KEYWORDS: Vojta-Therapy, Region Growing, Histogram of Orientation Gradient.

I. INTRODUCTION

The Vojta-Therapy is a technique used to treat the disorders in themusculoskeletal and central nervous system, and it is very useful for new born babies.The child suffering from such physical diseases isnot able to make some particular movements in their different body-parts, as normal way.VT is work on the theory of Reflex Locomotion, that is, the child's nervous system may be stimulated by applying the correct simulation. RL is considered as two ways oneReflex Creeping and another is Reflex Rolling and side lying positions, which makes child enable to do elementary patterns of movement inthem.

As per the Dr. V. Vojta we can notice motor reactions working throughout the baby's body when a particular stimulation is applied to him/her, while lying in Reflex creeping (a) prone lying position, and Reflex rolling (b) supine lying position and (c) side lying position.This therapy is applicable to the patients of any age group but it is most effective for new born babies that are because most of the developmental changes take place in the early stage of child life.For a remedy to achieve success; the therapy consultation of five-twenty minutes should be performed numerous times in a day or week and this technique can last for numerous weeks or months. Consequently, the therapists explain the purpose and objective of the remedy and advise an in-home continuation of the therapy as well. The therapy application is then determined in normal periods according to baby's development.

At some stage in the remedy, kids might also begin cry, inflicting the parents to be soreness approximately their baby's nicely-being. Resultantly, they stop the remedy in claiming that it isn't always beneficial. At this age, crying is the perfect manner of expression for the child patients, which after a quick familiarization duration, will become much less and much less intense. An automated vision based system is needed to analyze the accurate actions of a patient (i.e., accurate remedy), throughout the remedy consultation. The aim of home-based therapy assessment is to provide an correct in-home therapy alternative to in-hospital therapy. The therapy system at domestic isn't always most

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effective useful for the fast healing of a child patient however additionally pretty beneficial for individuals who do no longer have access to a local hospital offering said remedy. Moreover, the frequent visits to the therapist's health center add an economic burden as well.

In this paper, we proposed an automatic method for kid's detection and correct recognition of the motion patternsin his/her body parts in the course of VT, using video statistics. Theproposed technique operates in three steps. First, it converts video to frames,prepossesses it and segments the area of interest; We apply a region growing algorithm toextract the entire baby's body area from the scene. In second stage, the required features get extracted from segmented ROI using the HOG Descriptor. Third,the movements in the segmented infant's body area areanalyzed and classified the use of a support Vectormachine (SVM) with the help of features extracted in previous level. For the duration of therapy, a particular movement canbe observed in the infant whilelying in one of the aforementioned positions. We computedvarious features like x,y gradient, magnitude and Orientation and an SVM is exploited to classify the accurateactions, which in the end leads us to the correctness ofthe given remedy. The proposed approach is evaluated onour challenging dataset, which was collected in KIBS child health care center. The dataset contains more than 10 baby's video and its numerous motion pictures. Experimental results show that theproposed approach performs rather well and is pretty useful forat home-based therapy.

II. RELATED WORK

A. Human Detection

A large number of algorithms have been proposed forhuman detection in RGB and depth images. Numerous RGB based techniques generally used either object features such ashistogram of oriented gradient (HoG) descriptors [3] or motionfeatures like spatio-temporal interest points (STIPs) for thesaid purpose. Some other techniques exploited shape-basedfeatures and the interest points extraction from the scenesuch as scale-invariant feature transform (SIFT). Although most of these approaches claim high accuracy in humandetection,visual data still remains a challenging task due todifficulties caused by illumination changes, occlusions, as wellas complex and cluttered background. Alternatively, the depthdata has several advantages over the visual data as it provides3D structural information of the scene. Moreover, the layeredstructure of the depth data offers more details and importantcues for human detection and their action recognition.

Due to these advantages, many algorithms for human detectionhave also been proposed in depth images. Zhu etal. proposed a human detection by tracking his/her headand torso in depth images. They proposed the circle and box fitting to detect the head and torso respectively. In a support vector machine has been trained to discriminate the human head and shoulders for detection purposes. Thehuman upper body template is proposed in to slide over thedepth image and detect the human region using the Euclideandistance. Xia et al. proposed a human-head template forthe detection of a human in depth images using the 2D chamfermatching method. Stahlschmidt et al. proposed a humandetection technique using a matched filter known as Mexicanhat wavelet to the segmented foreground information of depthimage. This technique is only applicable when the camera ismounted in top-view position. Compared to these methods, theproposed algorithm does not require any statistical learning motion information, and is computationally inexpensive. Theproposed method exploits a fast template matching algorithm to detect the infant's body region using his/her head locationand segments it with more accuracy.

B. Rehabilitation

Industrial motion sensors have been utilized as a physicalrehabilitation tool. However, these methods requirewearing a number of sensors on the human body, causingdiscomfort. Virtual reality and motion-based games have alsobeen exploited for rehabilitation. Admittedly, theevidence indicates that these methods provide an interactive,engaging, and effective environment for physical therapy,but they require expensive hardware and software. They aregenerally designed to suit a very specific group of patientsand cannot be useful in cases of newly born babies becausethey cannot interact with such systems. With the invention ofa very low cost device, i.e., Microsoft Kinect, a new tool isnow to be considered in similar rehabilitation, as well as inassessment and monitoring systems. A Kinect camera is quitecheap and can be extended far beyond gaming It consistsof RGB camera, a 3D depth sensor that provides the

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distanceinformation of object from camera, and a pivot which can betilted either up or down direction for sensor adjustment.

Several researchers have utilized the Kinect as assistivetechnology at ambient assisted living and rehabilitation places.Authors proposed a system for in-home rehabilitationusing Dynamic Time Warping (DTW) algorithm and fuzzylogic. The evaluation is performed on the trajectory of jointsand the time duration in the completion of designated exercise.Exell et al. utilized the skeletal tracking information toanalyze the rehabilitation in the upper limbs. Chang et al.proposed a system that used the motion tracking of 6upper limbs for rehabilitation. For validation they used theoutputs of OptiTrack as ground truth and compared them to theoutputs of Kinect. Yao-Jen et al. developed a Kinect-basedrehabilitation system to assist the therapists in their work totreat the children suffering from motor disabilities. They usedthe motion tracking data to analyze the rehabilitation standardsand to allow the therapist to view the rehabilitation progress.Gama et al. proposed an interface for adults to monitor
the correct description of therapeutic movements. Therecent surveys on various therapy techniques for rehabilitationusing Kinect are presented. All of the abovementioned techniques used skeleton information from Kinect,which either could not be made available in the case of infantsor which was problematic if some body parts were occluded.Moreover, due to the nature of VT, some of the patient's bodyparts are always occluded.

Comparedto the aforementioned methods, the proposedalgorithm exploits only depth information for infant's detectionand used the segmented body region in combination withvisual information to classify the accurate movements in theirvarious body parts. To the best of our knowledge, we arethe first who proposed an automatic vision based system tomonitor the movement patterns infant's body region during VT

III. PROPOSED METHOD

The proposed method works in three steps. First: Imports video dataset captured by kinect camera and extracts frames from corresponding video and count them, further it read and pre-process each successive motion image .

At second stage: once RGB to gray conversion and median filtering of image is completed,segmentation of area of interest is carried out with the help of region growing algorithm. The process of seed selection may be perform manually or it can be selected automatically by using previous knowledge and Finally, we extract the various features in the segmentedinfant's body region to capture the movements of baby. The visual segmented information is utilized toonly identify the infant's lying position during the treatmentprocess. In the classification stage, a support vectormachine is used to classify the accurate movements of theinfant during the treatment.Following figure shows the overview of proposed method.

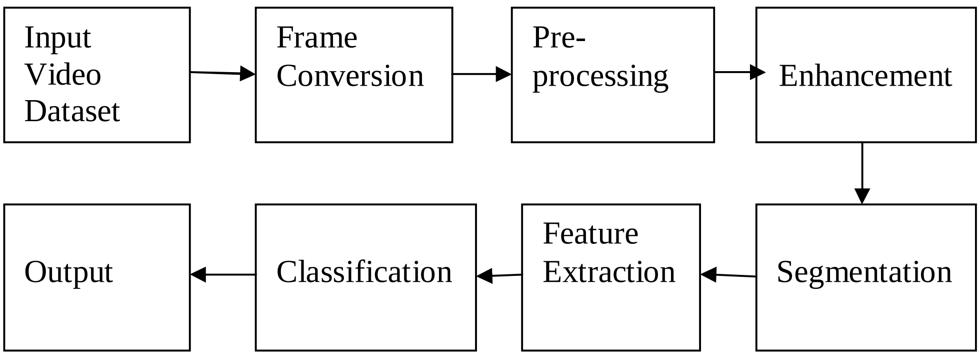

Fig.1 Overview of proposed method.

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Description of the Proposed Algorithm:

A. Frame Conversion and Preprocessing:

The 3Ddept sensor of the digital camera gives the intense information for the captured scene in the form of sequence of motion pictures. The proposed system takes this video as input and segmented each successive frame from it. Once the frames are get extracted, count the number of frames present in video and read frames.

Preprocess the image using the RGB to Gray scale convertor and filter the corresponding image using 4x4 median filter to remove the noise and to smoothen the image .Enhancement of the frames are done in order to improve the image quality to high.

Conversion Formula:

Gray scale=0.2989*R+ 0.5870*G +0.1140*B ……………………….eq(1)

B. Segmention

The Next task after the recovery of the missing pixel to read the frames one by one and locate the position of the child in the respective frame by segmenting the region of interest.The region Growing algorithm is used for the segmentation purpose, this algorithm selects seed point automatically based on appropriate criteria . A prior knowledge can be included, it is strictly application dependant . The region Grow is controlled by 8-connectivity.

Algorithm for ROI segmentation:

Given: f (x, y)=> the image to be segmented; S(x, y)=> binary image with the seeds (s= 1 only where the seeds are located); Q=> predicate to be tested for each location (x, y).A simple region growing algorithm(based on 8-connectivity). First, Erode all the connected components of S until they are onlyone pixel wide. Then Generate the binary image fQ such that fQ(x, y) = 1 ifQ(x, y) is true. Finally, Create the binary image g where g(x, y) = 1 if fQ (x, y) = 1and (x, y) is 8-connected to a seed in S. The resulting connected components in g are the segmentedregions.

C. Feature Extraction:

Once the child is extracted from current frame the relevant information need to be extract from it in order to recognize child's class accurately. Thus, histogram of orientation gradient descriptor used to extract various features such as x-gradient , y-gradient , angle(Orientation) and magnitude. Initially ,HOG normalizes the segmented image and then calculate gradients i.e. change in x-direction ,y-direction using bidirectional mask .And then calculate the angle and magnitude with the help of x-y values.

Calculation formulae:

Gradient computation:

$$f'(x) = \lim_{h\to 0}\frac{f(x+h)-f(x-h)}{2h} \quad \text{...........eq(2)}$$

Magnitude:

$$s = \sqrt{(s_x^2 + s_y^2)} \text{...........eq(3).}$$

Orientation: $\theta = \operatorname{atan}\left(\frac{s_y}{s_x}\right)$...........eq(4).

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Where,Sx is change in X- direction which use filter mask [-1,01], Sy is change in Y direction which use filter mask $[-1,01]^T$. Further, descriptor applies Weighted vote into spatial & Orientation cells to distribute the values in relative bin. We have considered 9 bins each of 20° (angle of move is 0 to 180),Contrast Normalize over overlapping spatial blocks . The steps B& C are repeated for each successive frame and at the end of last frame, collect all the HOG's over the detection Window.

Dalal and Trigss use 4 normalization factorsfornormalizing a cell histogram

$$N_{(\delta,\gamma)} = (\overset{\mathrm{m}}{\equiv} C(i,j))^2) + \left(\overset{\mathrm{m}}{\equiv} \left(C(i+\delta,j)\right)^2\right) + \left(\overset{\mathrm{m}}{\equiv} \left(C(i+j+\gamma)\right)^2\right) + \left(\overset{\mathrm{m}}{\equiv} \left(C(i+\delta,j+\gamma)\right)^2\right)$$

$where\ \delta,\gamma \in \{-1,+1\}$................eq(5).

HOG feature map is obtained byconcatenating normalization results
:

$$H(i,j) = \begin{bmatrix} T_\alpha\left(c(i,j)/N_{-1,+1}(i,j)\right) \\ T_\alpha\left(c(i,j)/N_{+1,-1}(i,j)\right) \\ T_\alpha\left(c(i,j)/N_{+1,+1}(i,j)\right) \\ T_\alpha\left(c(i,j)/N_{-1,+1}(i,j)\right) \end{bmatrix}$$ where T(v) is truncation function with a...........eq(6).

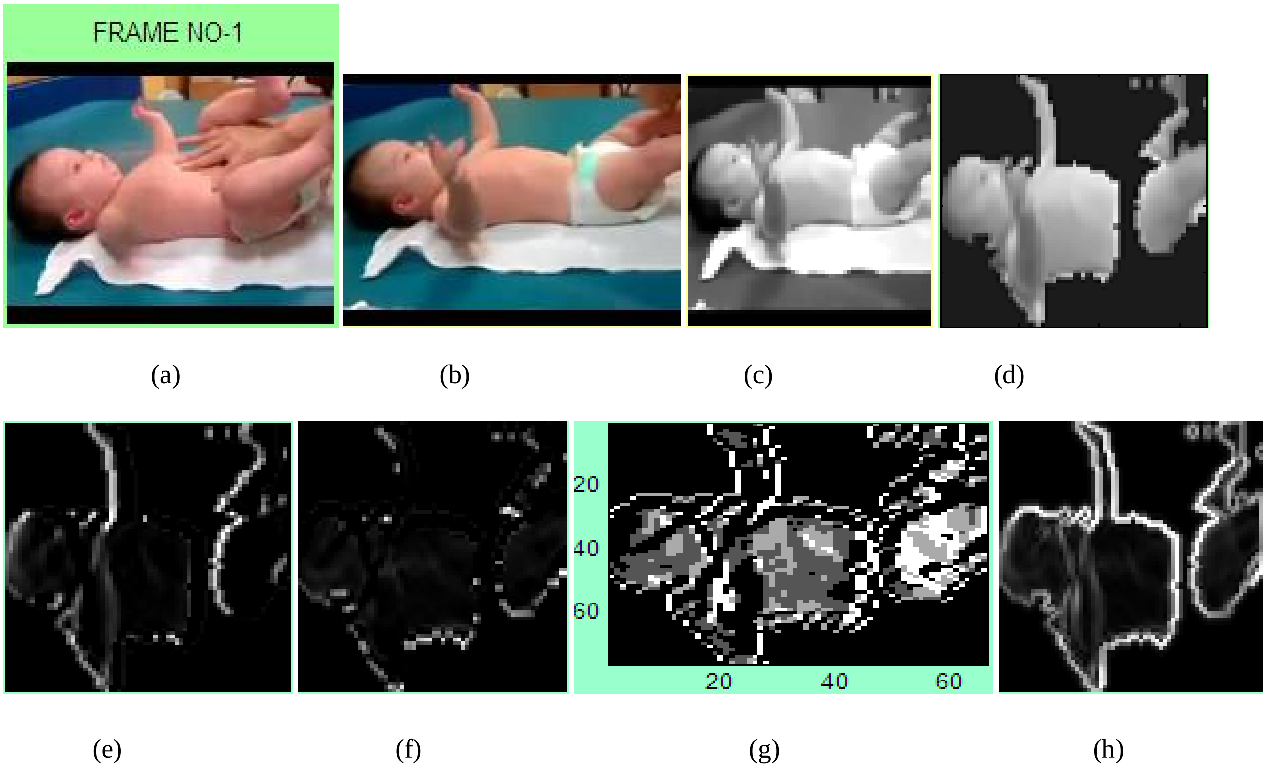

Fig.2 .(a)shows the frame 1 has been read from video input data, (b)Frame 1 as input to proposed algorithm ,(c)Enhanced image ,(d)Segmented ROI, (e) measure in X- direction ,(f) measure in Y- direction, (g)Orientation for image one. (h) Magnitude image.

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D.Classification

The therapy is given to infants in prone, supine, and side lyingpositions. In our work we primarily focus on the treatmentin prone and supine lying positions. We declared two trained classes for classification of the child under observation in classA is abnormal if peak HoG's are located to same bin position, it means that there is no change in angle and magnitude of child is seen for all the frames, thus we can say that child patient is unable to move and we may conclude that the child under observation is Abnormal.

Where asclassB normal class is selected if the peak of the HoG's varies from bin to bin throughout the frames, which tells that there is certain changes are seen in angle and magnitude.Thus we can say that child patient is able to move and we may conclude that the child under observation is normal.

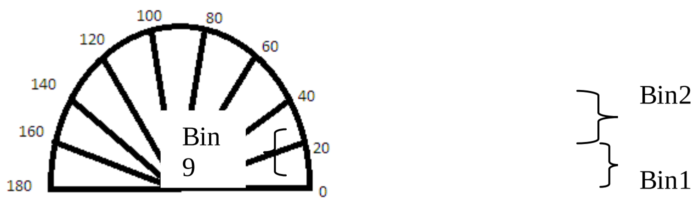

Fig.3 Bin Definition

FlowChart for SVM Classification:

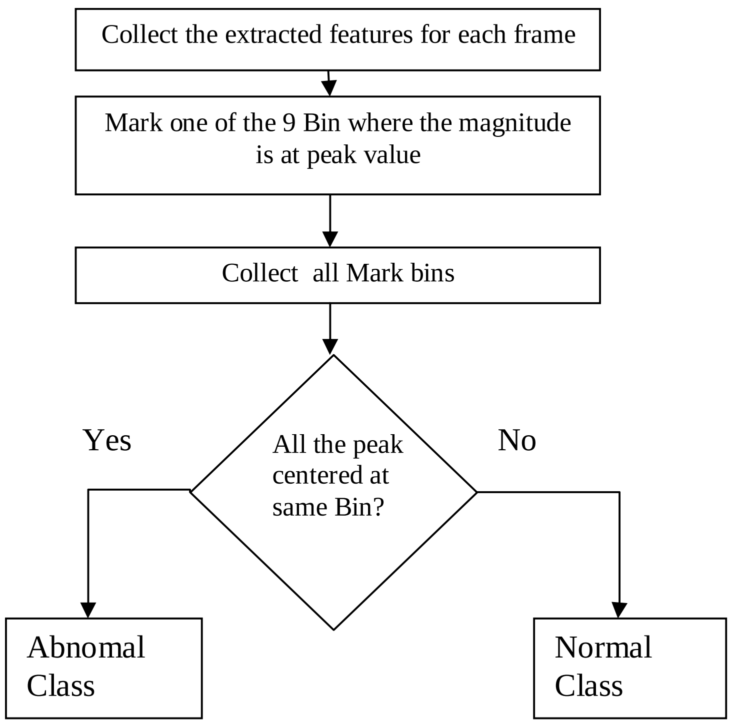

Fig.4 flowgraph of classification process

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IV. EXPERIMENTS & RESULTS

We captured more than 10 videos containing thousands of frames of child of the various age (2 weeks to 6 months).The camera wasput on a tripod, at the height of 2 meters and with an angleof 45◦ from the table surface (where the infant is lying for therapy), as shown in Fig. 5. The setting was chosen to be inaccordance with the recommendation for capturing the best data quality.

Fig .5 Example of camera setup during the therapy.

A. Detection Performance

The proposed detection algorithm is applied on our collectedchallenging dataset for infant's detection using only depth Information. We achieved the detection rate of 92.4% . The reason for the drop indetection rate is due to the occlusion at the location of theinfant's. Although it was pre-decided with the therapiststo use their hands with the minimum occlusion of the infant's body structure, the situation was particularly often faced whenthe treatment was given in side,supine as well as prone lying position, as shown in Fig.6

(a) (b) (c)

Fig.6 Example of body poses during the therapy. (a) an infant with clear body structure in supine lying position, (b) occlusionin the infant's body structure can be observed in prone lyingposition due to the therapist's hand.(c)an infant with body structure in side lying position.

B. Classification Results

SVM has been used as a powerful tool for solving classificationproblems in many applications. Due to the highdimensionality of our features, we decided to use SVM asclassifier. In the comparison of SVM, the other similaritybased classifiers like K-Nearest Neighbor and probabilitybased classifiers like Naive Bayes do not perform

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well for high dimensional features . SVM first maps the training samplesin high dimensional space and then extract a hyper-planebetween the different classes of objects using the principleof maximizing the margin. Because of this principle, thegeneralization error of the SVM is theoretically independentof the number of feature dimensions. using its one-against-one version. It uses two-class SVMsfor each pair from a set of all considered classes. Thus,for N classes in total, $N(N-1)/2$ two-class classifiers areconstructed. It uses voting strategy for classification and eachtesting sample is classified to the class with maximum numberof votes.In this paper, we used the implementation of SVM withinthe *LIBSVM* library . We used the C-Support VectorClassification formulation with the soft margin parameter $C$and, γ when RBF kernels are used as meta-parameter. A 5-fold cross-validation is performed to validate the model with the selection of the above mentioned meta-parameters prior toit training the actual model on the full training dataset. Tab.1 summarized the classification results of SVM for accuratemovements limbs during the treatment.

(a) (b)

Fig.7(a) peak HoG's distribution for ClassA, (b) for classB.

Fig.7 (a)shows that all the resultant HOG's are located at 5th bin which conveys that baby had no change in angle of his body posture which ultimately says that baby is still disable to move without any external simulation and we may conclude that child under therapy is abnormal. Where as fig 3(b)conveys totally opposite of (a).,here Resultant HoG's varies from bin to bin means the angle of baby posture is continuously changes and we may conclude that now the baby is quite able to do moves and it is at normal condition.

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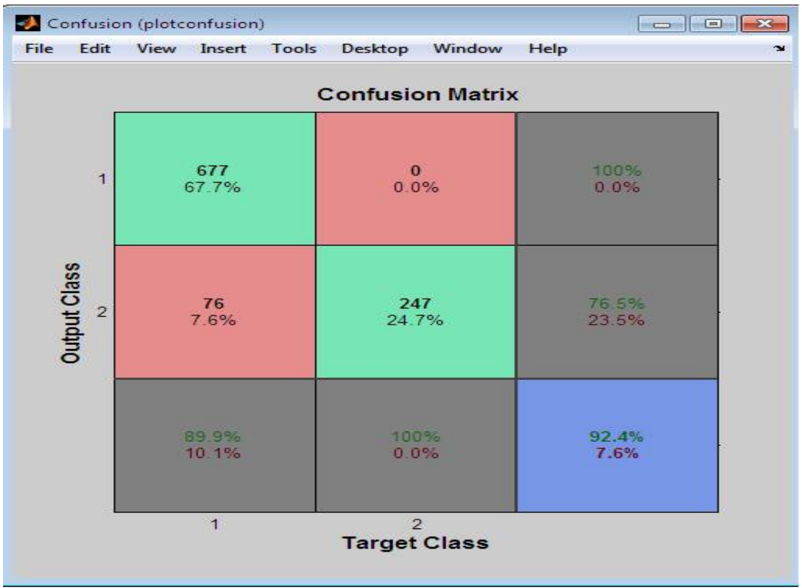
TABLE I: Classification rate of the proposed algorithm



V .CONCLUSION AND FUTURE WORK

In this paper, we proposed an automatic method for infant'sdetection and accurate recognition of movement patterns duringVT. The proposed method works in three steps. First, weextract the frames from video and preprocess image.Second,segment an infant's body region from depth imageusing region based algorithm. Finally, the movement patterns inthe segmented infant's body are analyzed and classified usingSVM. The experimental results show that the proposed methodperforms well and can be used for in-home based vojta-therapysystems to recognize the normality of infant. In future,we plan to implement the algorithm in depth databy including a few other motion features for detection and classification. Our Target is not only stopping here but to implement more of this advance to this system in near future and make it more efficient and accurate recognition system.

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