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Assesment of neuromotor functioning of infants using motion vector analysis of video object tracking

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Abstract: Video based assessment for infant aged to 3 to 18 month carried out some of the important neuromotor assessment like, infant motor profile(IMP),Harrison infant neuromotor test(HINT),Alberta infant motor scale(AIMS),Hammersmith neurological examination(HINE),Bayley scales of infants development examination(BSID),Peabody development motor scale (PDMS).this type of test helps in diagnosing the neurophysiological maturity of babies basically in between 6 month to 18 month. This test conducted to locate the suspected disability of infants. In this paper we have concentrated on the specific HINE test of neuromotor function. In this test we have done the analysis of pull to sit examination of infant using motion vector analysis of video processing. The entire process of HINE depend upon the examiner associated with the test which include the pull to sit and lateral tilt which seems to be difficult in observing on naked eyes. It is very much essential to observe deeply the movement of head with respect to torso by pulling the infant by holding the wrist. So solving this problem and the accurate result can be obtained by applying video based object tracking. In this paper we had gone through the method of analyze the automated pattern of pull to sit examination. In this the dominant color reference method and various angle between the head and torso can be measured by mat lab analysis and motion vector analysis of video processing and kalman filtering.

Keywords: Hine, Kalman Filtering, Motion Vector, Object tracking, Pull to sit experiment

I. INTRODUCTION

Video surveillance is a primary and most essential objective in the countries frontline system whether it is defense or medical or any sorts of entertainment. It is applied everywhere. Day to day life often surrounded by application of various video surveillance. Urban life demands more safety and security so various domain video surveillance is implemented by means of desired utility.

Object tracking is the most advanced application of video surveillancein which we concentrate on particular movement of the object focusing on the various observation. Large number of video object tracking is used for monitoring in the structured environment. An application of the structured environment means the moving object is being tracked under the various environment condition. It is important to notice all the primary and secondary environment factor under consideration to improve the performance of tracking. To march towards the technology behind the object tracking suggests two classes [1]. Object representation and localization [2]. Filtering and data association. This two technology deals with mean shift tracking which simply uses the color histogram. This two method of object tracking normally gives the maximum information about the object avoiding the environment condition acted upon it. So it is least effective in the factor of improving the performance.

Similarly filtering gives the data modeling and various framework of the motion characteristic ignoring the environment factor. So these two method of tracking doesn't hold good for any improvement factor.

To overcome such problem background substitution methods are used which subtract the object from the background and up to some extend it improves the factor of environment. An object tracker which works on the clustering foreground pixel using a modified K mean algorithm followed by linier prediction is used for detecting an object.

Learning based methods are useful for detection of object and behavior prediction. Distance transform is another factor which gives the most advanced tracking including all the environment factor under consideration. This paper is based on different application of video processing in the domain of object tracking. Here object tracking is applied in medical application in which the mental status of the infants being measured by the process of Hammersmith pull to sit examination. Various moment of head of the infant with respect to torso is located by using video processing.

Video based assessment for infant 3 to 18 month with a moderate sever development that is motor disorder consist of several items organized to 5 suspect

1. Variability

2. Symmetric
3. Fluency
4. Performance

It is the assessment test for possible motor and cognitive development disorder used for the infants between 6 and 12 month of age. Here infant is observed when place in or allowed to supine the prone sitting and standing position behavior and cooperation. In this case we observe the mobility spine neck reflex action. Testing of infants provided simulation or is handled by the examiner to determine the scores. Currently very few neuromotor assessments are available for the infant at the age of 6 to 24 months.

To increase the survival and birth rate advanced neonatal care are performed some of the neuromotor experiment. Child normally born at the gestational age bellow gestational age bellow 34 weak might have chance to occurred disabilities. Some prematurity causes humor or peri ventricular lucomalacia and increasing the chance of cerebral palsy. In such case we have to predict the various clinical test .HINE is one such approach for the parametric test of the infant which born between 2 to 24 of estimated age. In terms of clinical test HINE is conducted by the process of visual observation.

Visual observation doesn't provide accuracy according to the desired output so pull to sit is difficult to perform. So video based object tracking methods are used to bring the accuracy of the test .various image of the infants are observed by implementing two cameras.

II. SILENT FEATURE OF HINE

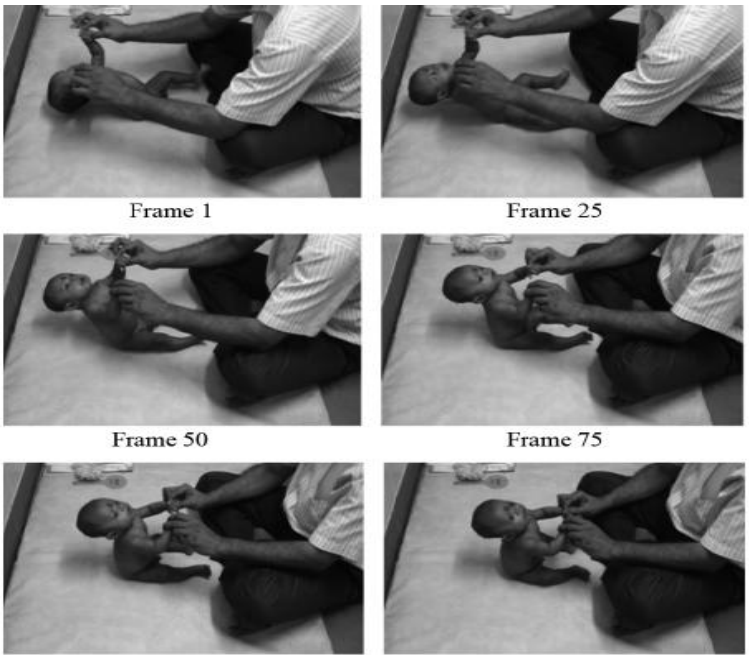


Fig.1. Silent feature of Hine

This is the typical Hine experiment in which several position of the infant is observed and this test started Seth SukhlalKarnani Memorial (SSKM) hospital, Kolkata , India . The prime factor of this experiment is that the behavior of the head movement with respect to torso is being located with respect to pull to sit. It was expected that in the case of normal baby when the pull to sit experiment is performed, means when the head is moved with respect to torso the baby can be recovered its position but in the case of abnormal when the head is moved it cannot be recovered the original position

Since aim of the examination being conducted on the basics of angle between head and torso it deals with the various score. Though it's a completely based on observation, it's a big challenge for the observer precession

There is a greater chance of variance of error when examination being conducted. So depending on the observer precession, accuracy cannot be expected so video based test is a number of applications in medical informatics domain adopt computer vision-based solutions. For example, Bhattet al.have proposed a video-based infant monitoring tool that successfully recognizes the event when an unattended baby puts something into its mouth. Similarly, the tool developed by Singh is a tele monitoring system which can be used for remote

surveillance of infants. It was developed using safe, compact sensors to produce some of the desired output with a client server architecture.

Video enabled tools are also used in the follow up process for monitoring patients and their behavior. However, other than the visual recording system proposed by the authors of no work has so far been reported in the literature that tries to automate the analysis of HINE. The above mentioned factors have motivated us to design video-based algorithms that can help the physicians conducting these examinations. Such algorithms will facilitate estimation of parameters that are used for analyzing of pulled-to-sit, lateral tilting, ventral suspension etc.

III. PROPOSED METHOD

Morphological operation of pull to sit examination

Morphology is the mathematical operation which deals with the study of shape. In this work morphology plays an important role because various movement of the infant is being studied so we have to analyze the shape of the body with respect to reference. In image processing,mathematical morphology is used to investigate the interaction between an image and a certain chosen structuring element using the basic operations of erosion and dilation. Mathematical morphology stands somewhat apart from traditional linear image processing, since the basic operations of morphology are non-linear in nature, and thus make use of a totally different type of algebra than the linear algebra .Although the mathematics behind this1 is fascinating, treating it here would be beyond the scope of this book. In practical image processing, it is sufficient to know that morphology can be applied to a finite set.

We can partly order its element can be denoted by ≤

All a,b,c € p

a≤ a

(a≤b,b≤ a) => a=b

The side view camera records the scene of pulled-to-sit examination in sagittal view. In such a scenario, movement pattern of the baby can be modeled using the stick diagrams shown in Relative movement of head and torso can be estimated in the 2-D projected space. Movement of the infant along the -axis (optical axis of the camera) can be ignored for this examination and the projection of the video frame on plane can be used for the analysis. It has been observed that during this examination, the bottom part of the torso (hip) works like a hinge and the entire body goes through a 90 rotation. In order to estimate relative movement between head and torso, one more hinge is introduced at the shoulder. When the baby lifts the head along the central axis of the torso, it is expected that the head will follow the torso and both will have a similar kind of motion as depicted in A (X1,Y1), B (X2,Y2) AND D (X3,Y3) denote three points representing the head ,shoulder and hip respectively.

$$[\chi' \quad \gamma' \quad 1] = [x \quad y \quad 1] \times T_1 \qquad (1)$$

Once the coordinates of the feature points are updated, motion of the torso can be analyzed. Assuming that the line segment denoted by $\overline{BD}$ represents the central axis passing through the midpoint of the baby. We have to estimate the angular velocity of the baby with respect to point D. suppose $\overline{BD}$ make an angle $\phi(\angle BDE)$ with the positive X axis.

At the time $t = t_i$,gradient of $\overline{BD}$ is $\tan\phi_i$ and its rate of change of estimated using the equation

$$\Delta m_1^{\,i+1} = \frac{\delta(\tan\phi_{i+1} - \tan\phi_i)}{\delta(t_i + 1 - t_i)} \qquad (2)$$

Next we have to align the $\overline{BC}$ and $\overline{BG}$ along the x axis and y axis rotation and applied to the rotational matrix simply simplify the motion analysis of head of the baby

$$[x'' \quad y'' \quad 1] = [x' \quad y' \quad 1] \times R \qquad (3)$$

$$R = \begin{bmatrix} \cos(\phi - 90^o) & -\sin(\phi - 90^o) & 0 \\ \sin(\phi - 90^o) & \cos(\phi - 90^o) & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad (4)$$

Head movement can be can be quantified as using the above analysis.

The rate of change of gradient of $\overline{AB}$ with respect to B can be estimated by the following equation

$$\Delta m_2^{\,i-1} = \frac{\delta(\tan\alpha_{i-1} - \tan\alpha_i)}{\delta(t_{i-1} - t_i)} \qquad (5)$$

Based on following equation we can measure the various angle of the head movement of the infant.

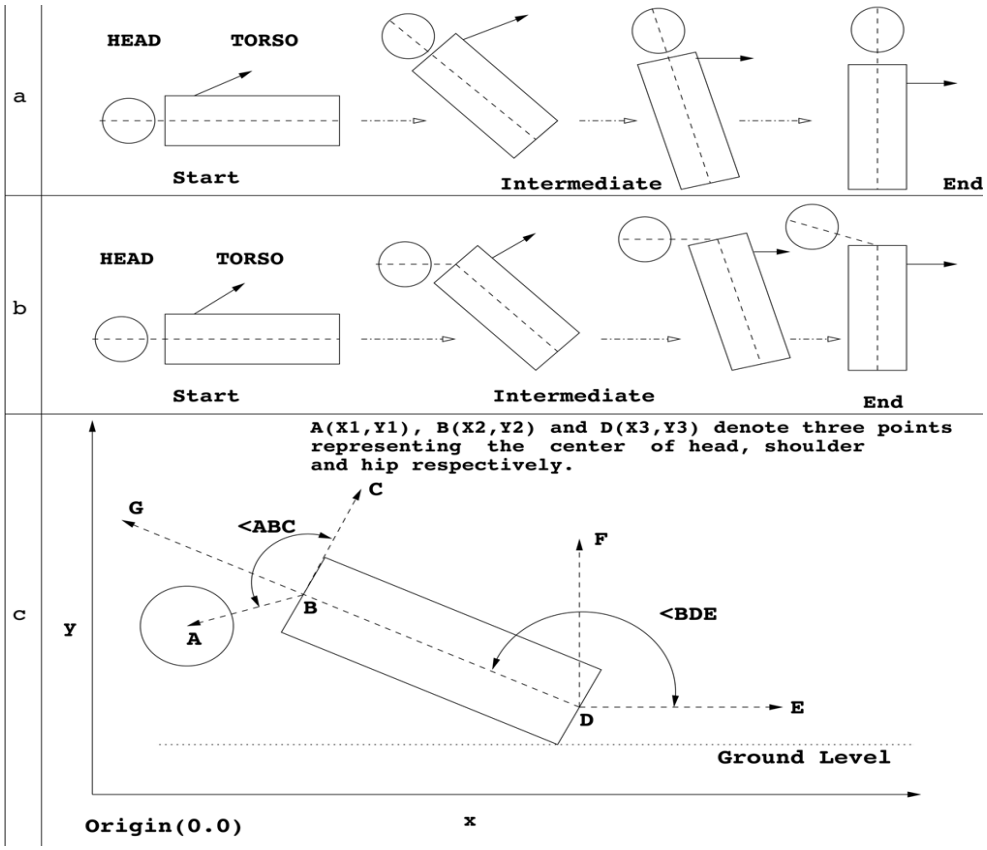


Fig.2. Relative movement of head and torso can be estimated in the 2-D projected space

Position detection and position updates

In this project we have taken the most important care about the position of the infant when it located in the first.Feature point-based unsupervised algorithms largely rely on detecting global features, which may not be practical for all applications. For example, even a smallerror in locating feature points can degrade the performance of tracking. In addition, unsupervised algorithms are computationally time consuming and often do not meet timing constraints for some real life applications.

A feature point in one frame may match with multiplepoints in the subsequent frame, resulting in ambiguity in feature correspondence. Though various algorithms have been proposed to resolve such ambiguity, these algorithms often use exhaustive search such as FSBM and correlation over a large neighborhood for correspondence. Such techniques also incur high computational overhead and may not be suitable for real time tracking.

Even algorithms using optimized searching methods sometimes fail to track some feature points tested with the available HINE recording, it has been observed that block matching-based algorithms often fail to track points of interest. Since the infants are kept unclothed during the examinations, foreground objects tend to have similar color and texture.

This leads to multiple matches and non-unique identification of the feature points in successive frames. A small error introduced at each step would propagate and cause the failure of the tracking process. Feature point-based object tracking algorithms try to detect landmark points in every frame and relate these points based on some criteria assuming that the object is rigid.

Camera set up for position detection and position updates.

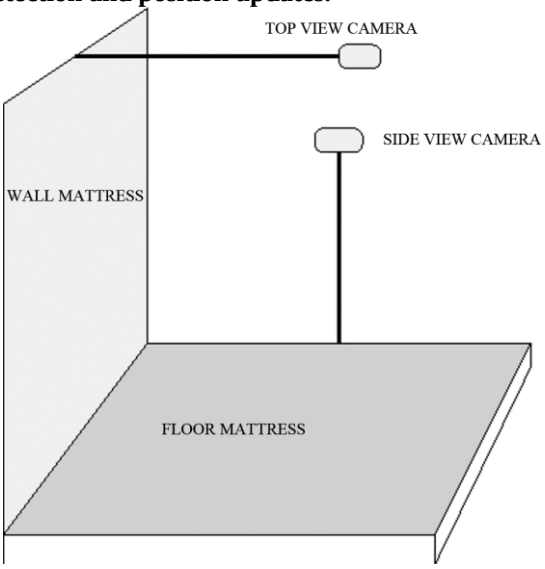


Fig.3.Camera set up for position detection and position updates

Visuals recorded from a single view may not be sufficient for automatic analysis since HINE assessment involves measurement of angles between various body parts, detection of postures, understanding reaction of the baby, and tracking bodyparts. Thus, pulled-to-sit, trunk and head position in sitting,popliteal angle measurement are viewed in sagittal plane (sideview) since these examinations can be analyzed from the perspective projection of the corresponding frame in xy plane and z axis in the real world co-ordinates is parallel to the optical axis of the camera. On the other hand, adductors angle measurement and arm analyzed if videos are recorded in coronal viewprotection can better be analyzed if recordings are taken from the top. There are some examinations like lateral tilting, ventral and vertical suspension, which can be a typical arrangement as shown in has been used for data acquisition. Side view camera was used for recording sagittal. We have used a specified version of camera in which recording of the infant was taken.

I have used the Kodak easy share C182 digital camera having specification of 16 mega pi camera of video output of PAL and firmware version of 1.0000 with USB connectivity with USB cable.

To reduce the error during various image processing steps, examinations wereconducted in a controlled environment with fixed illumination.

The examination desk was covered with a soft mattress. This was done in accordance with the well-established setup of the neuro-development clinic of the SSKM Hospitalin order to analyze Hammersmith examination recordings, it is often necessary to track individual body parts of the infant under examination. The problem of object tracking in videos has been extensively investigated.

Many such tracking algorithms depend on block matching criteria like full search block matching (FSBM) and variations of FSBM such as diamond search (DS), directional diamond search (DDS), three step search (TSS), and new three step search (NTSS). These methods try to optimize the size of the search window based on various criteria.

Alternatively, feature point-based tracking algorithms, where a feature point is selected and tracked by analyzing the motion of the block containing the feature point, have also been proposed. Some of the problems encountered by the existing object tracking. Noise plays some important part so Kalman filtering is used for removing noise.

Identification of Kalman estimation & update and compare with reference

Kalman filtering, also known as linear quadratic estimation (LQE), is an algorithm that uses a series of measurements observed over time, containing statistical noise and other inaccuracies, and produces estimates of unknown variables that tend to be more precise than those based on a single measurement alone, by using Bayesian inference and estimating a joint probability distribution over the variables for each timeframe. The filter is named after Rudolf E. Kálmán, one of the primary developers of its theory.

The Kalman filter has numerous applications in technology. A common application is for guidance, navigation and control of vehicles, particularly aircraft and spacecraft. Furthermore, the Kalman filter is a

widely applied concept in time series analysis used in fields such as signal processing and econometrics. Kalman filters also are one of the main topics in the field of robotic motion planning and control, and they are sometimes included in trajectory optimization.

The Kalman filter has also found use in modelling the central nervous system's control of movement. Due to the time delay between issuing motor commands and receiving sensory feedback, use of the Kalman filter provides the needed model for making estimates of the current state of the motor system and issuing updated commands.

The algorithm works in a two-step process. In the prediction step, the Kalman filter produces estimates of the current state variables, along with their uncertainties. Once the outcome of the next measurement (necessarily corrupted with some amount of error, including random noise) is observed, these estimates are updated using a weighted average, with more weight being given to estimates with higher certainty.

IV. RESULTS AND DISCUSSIONS

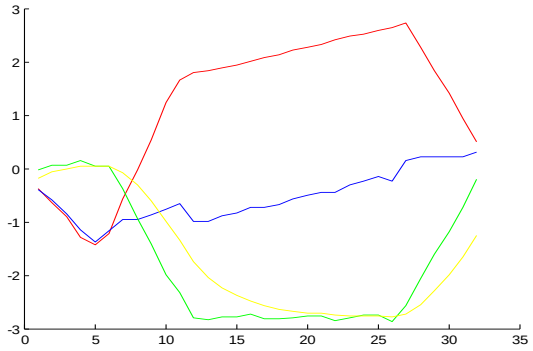
The algorithm is recursive. It can run in real time, using only the present input measurements and the previously calculated state and its uncertainty matrix; no additional past information is required.

The Kalman filter does not require any assumption that the errors are Gaussian .However, the filter yields the exact conditional probability estimate in the special case that all errors are Gaussian-distributed.

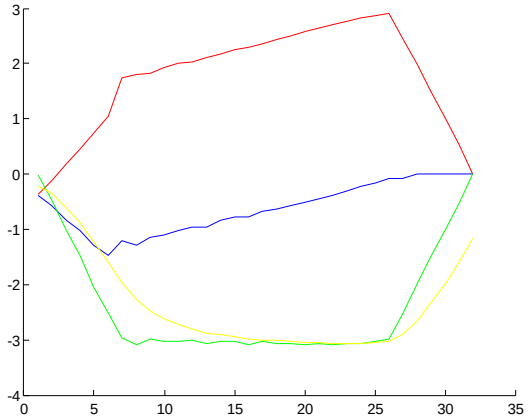
Table-1

Score	3	2	1	0
Description of events	Head of the baby follows the torso (15° is acceptable)	Not used	More than one the baby pulls the head it is 30°	Head retains bellow 30°

Matlab based results and graph



1. Graph of angle between head and torso of healthy baby.



2. Graph of angle between head and torso of unhealthy baby.

V. CONCLUSION AND FUTURE WORK

HINE is a successful test in gathering information in premature stage, if any fault condition arises then it can be rectified earlier. In India there is a lack of information and very less test available for the babies lies between 6 month and 12 month. In this work basic focus has given the motion vector analysis which gives the better prediction rate of the movement of the baby and that can be estimated a proper value.Kalman filtering played a vital role in making the output smoother with its threshold value.This work can be enhanced and implemented in every common hospital to create the awareness and more informative.The proposed approach can be used by trained paramedics as a decision support system.There are a few limitations of the current application which need to be addressed in future. Firstly, an extensive field trial is necessary for validation and standardization of this tool.

Idea is also there working towards developing algorithms for dealing with lateral tilting and ventral suspension types of Hammersmith examinations with the help of 3-D tracking. Hine is an advance and rare neuro motor test .various infant's disease can be predicted by the gesture and movement of the organ several domain of research is going on 3d view of baby and can be modeled to estimate more productive manner. It is going on and propose to implement in normal hospital to make it more user friendly.

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