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Human Motion Tracking and Analysis via Point Tracking Technique

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Abstract

The main objective of this paper is to present a two-dimensional vision system for human gait motion analysis and provides pertinent information on human walking parameters. These information will be useful in determining the any possible walking deficiencies for patients such as the elderly and infant. The proposed method is based on human motion tracking using optical flow technique, which is a type of point tracking techcnique. The body will be represented by coloured points or markers on targeted section of the body. The coloured points will be set according to the arm kinematics chains for upper arm, lower arm and hand From the results, it can be seen that crucial information of the dynamic body motions can be acquired and used as reference for further analysis.

Introduction

The tracking and recognition of human motion is a challenging problem with diverse applications in virtual reality, medicine, teleoperations, animation and human-computer interaction [1]. However, clinical usefulness of quantitative gait analysis has been increasingly reported. Opto-electronic systems are commonly used for these applications, and most of the methods proposed calculation of kinematics and kinetics refer to markers attached to the skin [2].

Human motion analysis is a very difficult problem to tackle. The human body is an extremely complex object, being highly articulated and capable of doing bewildering variety of motions. Rotations and twists of the body parts occur in nearly every movement, and various parts of the body continually move into and out of occlusion. That is why human body has to be treated as a non-rigid body. According to *H.Nugroho et. al* [3] occlusion can introduce significant problem in the recognition task. Another obstacle that has to be dealt with is the clothing which can have a large influence on the appearance of a person. Clothing can also cause complex illumination phenomena that will change during movement. To keep the problem within a manageable limit, some restrictions are usually introduced, i.e. limiting only one person in a scene [4 &5], considering human as a 2D moving object.

Methodology

The system is implemented using a real-time CCD camera that is connected to a computer for image acquisition and analysis. The camera will capture human's upper-body and the images will be displayed at the computer terminal.

Position of the camera must be locationed parallel with the upper-body section. In this case, since we would like to focus on the hand movements, so the best views to capture arm motions are from the side and front view of the upper-body (see Figure 1 and Figure 2).

Images that are captured from the CCD camera are converted to grayscale images. Grayscale images intended for visual display are typically stored with 8 bits per sampled pixel, which allows 256 intensities [6]. The arm kinematics then will be represented by a set of points that are set by the user.

Three coloured points or markers are set according to the arm kinematics chains for upper arm, lower arm and palm [7]. In a constrained tracking scenario, the points representation is found to be most economical and suitable, especially when the acquired data will need to be processed further [8].

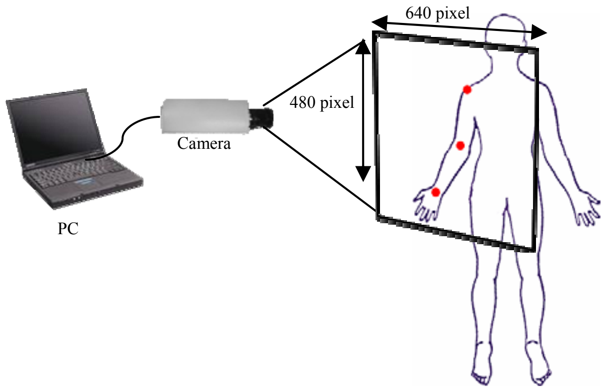

Figure 1: System setup for arm kinematics tracking

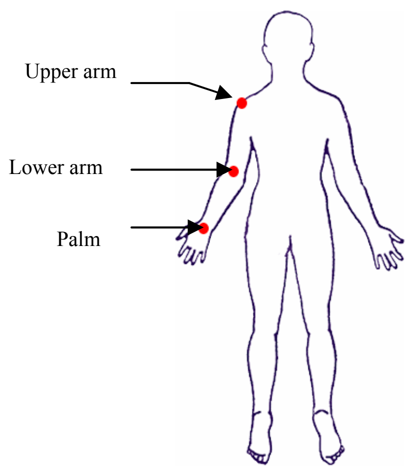

Figure 2: Arm Kinematics Chain

Point tracking and Optical Flow

In our system, in order to track the arm kinematics, we proposed Shi and Tomasi method [8][9][10] as tracker algorithm. This algorithm employs the use of Lucas-Kanade on carefully chosen corner points which met the minimum eigenvalue criterion. This ensures that the matrix is well conditioned and above the noise level of the image so that its inverse does not unreasonably amplify possible noise in a certain critical direction, i.e. there are sufficient spatial gradients in two orthogonal directions. Nevertheless, for our system, the tracker will focus on the three chosen coloured points or markers that represent the overall hand movement.

The motion vectors for each of these coloured points could then be calculated using Lucas-Kanade optical flow algorithm which involves its pyramidal implementation as given by Bouguet[11]. It calculates coordinates of the coloured points on the current video frame (I_2) given their coordinates on the previous frame(I_1). The function finds the coordinates with sub-pixel accuracy using bilinear interpolation. The displacement vector (v_x, v_y) of the feature point (p_x, p_y) between two images $I_1(x, y)$ and $I_2(x, y)$ is defined within a window size of w_x around the feature. The goal is to find the displacement vector (v_x, v_y), which minimizes the cost function €(v), as in equation (1):

$$€(v) = \sum_{p_x-w_x}^{p_x+w_x} \sum_{p_y-w_y}^{p_y+w_y} (I_1(x, y) - I_2(x + v_x + g_x, y + v_y + g_y))^2 \quad (1)$$

Pyramidal implementation of the classical Lucas-Kanade algorithm provides sufficient local accuracy and handle large motions.

Preliminary Experimental Results

We have conducted two experiment to demonstrate the hand movement tracking. The experiment was conducted in a normal lab environment with ceiling lightings. This test implement the point tracking and optical flow algorithm on Visual C++ environment and all test have been conducted on a 3.2 GHz Pentium IV machine executing Windows XP.

The algorithm detects the arm kinematics orientation coordinate for each coloured points on the 640x480 dimension images. If the one of the arm kinematics is outside the image region of interest (ROI), occlusion will occur. This will give an error result to the tests.

For the first experiment, the camera was only focused on the right complete arm kinematics chains which are the upper arm, lower arm and palm sections. During the experiment, the person was standing static at a point which was parallel to the static camera and then started to swing forward and backward (see Figure 3).

Figure 4 shows the graph of the arm kinematics orientation versus time. In the first sector of the graph shows the arm is swing forward direction while the second sector shows the arm back to the normal position. The third section is where the arm start swings backward and fourth section shows the arm back to the normal position. Fifth section is where the lower arm starts to bend. Overall, from the graph, we can see that upper arm is not moving as frequent as compared to the lower arm and palm section. The

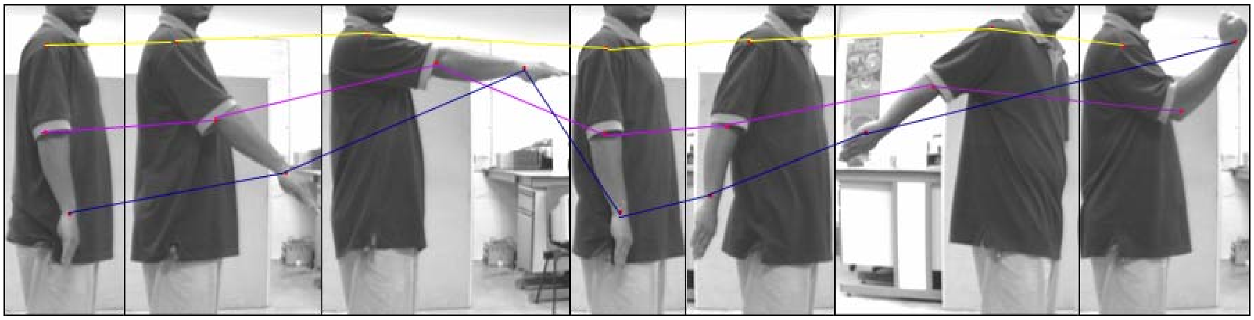

Figure 3: The Arm Kinematics Orientation from the side view

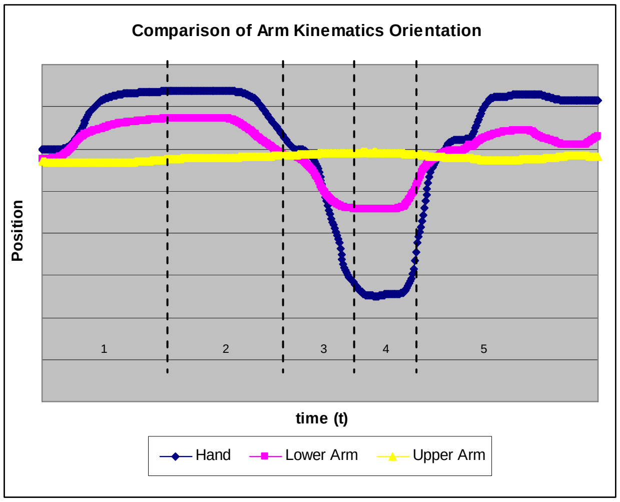

Figure 4: Comparison of Arm Kinematics Orientation

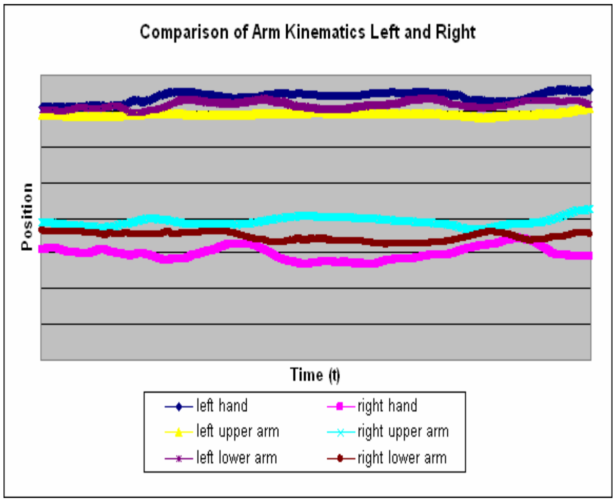

Figure 5: Comparison of Arm Kinematics Left and Right

orientations of lower arm and palm section are quite similar although the positions are different.

In the second experiment, the camera captures the front view of the upper body. This experiment shows the comparison of arm kinematics left and right (see Figure 5 and 6).

The data acquired shows possible that can be acquired from the tracking application. The frequency, amplitude, orientation and composite velocity of the motion can be plotted and analysed. These tests were conducted on video, i.e. dynamic data, and then processed subsequently.
Figure 6 shows the gait analysis from frontal view. The analysis indicate possible determination of walking gait analysis for a normal person.

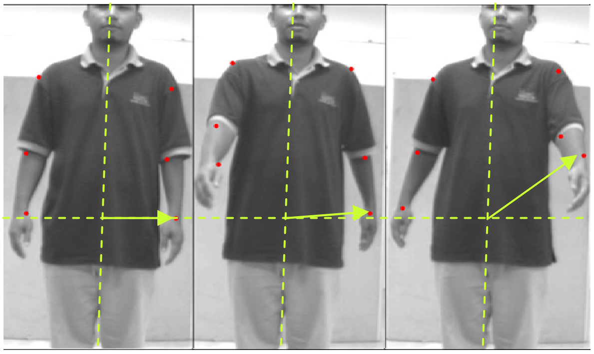

Figure 6: The Arm Kinematics from front view

Conclusion and Further Work

In this paper, point tracking technique using optical flow method is proposed for human motion analysis. This technique will enable analysis to the gait activities based on the 2D representation of human motion. The main consideration is the direction of the movement of joints and to minimum the occlusion. Although this preliminary investigation has not tackled the problem of occlusion, it has shown significant performance. Further calibration and parameter specification need to be done before a proper gait analysis system can be completed. For further improvement, it is suggested that this set-up be implemented on real motion related analyses such as for Parkinson's disorder and related movement-related disability study.

References

[1] Micheal J. Black, Yaser Yacoob, Shanon X. Ju, "Recognizing Human Motion Using Parameterized Models of Optical Flow", website (Mac 2007) : http://www.cs.brown.edu/~black/Papers/shahChapter.pdf.

[2] C. Frigo, M. Rabuffetti, D. C. Kerrigan, L. C. Deming, A. Pedotti, "Functionally Oriented and Clinically Feasible Quantitative Gait Analysis Method", Med. Biol. Eng. Comput., 1998, 36, 179-185.

[3] Hertog Nugroho, Junghyun Hwang, Shinji Ozawa, "Tracking Human Motion In A Complex Scene Using Textural Analysis", Volume 2, 5-9 Sept. 1994 Page(s):727 - 732 vol.2 Digital Object Identifier 10.1109/IECON.1994.397875

[4] Maylor K. Leung and Yee-Hong Yang, "Human Body Motion Segmentation in a Complex Scene", *Pattern Recogni*tion *Vol. 20 No.* 1, 1987, pp 55-61.

[5] Joseph O'Rourke and Norman I. Badler, " Model-Based Image Analysis of Human Motion Using Contraint Propagation", *IEEE* Trans. *PAMI,* Vol. PAMI-2, No. 6, Nov. 1980, pp 522-536.

[6] Wikipedia, The Free Encyclopedia, http://en.wikipedia.org/wiki/Main_Page

[7] Roman Filkorn, Marek Kocan, "Simulation of Human Body Kinematics", website (Mac2007): http://www.cescg.org/CESCG-2000/RFilkorn/

[8] Alper Yilmaz, Omar Javed, Mubarak Shah, "Object Tracking: A Survey", ACM Computing Surveys, Vol. 38, No. 4, Article 13, Publication date: December 2006.

[9] Helmy Eltoukhy, Khaled Salama, "Multiple Camera Tracking", website (Mac 2007): www.stanford.edu/class/ee392j/Winter2002/projects/Eltoukhy_Salama/track2.ppt

[10] Fabrice Bourel, Claude C. Chibelushi, Adrian A. Low, "Robust Facial Feature Tracking", website (Feb 2007): http://www.bmva.ac.uk/bmvc/2000/papers/p24.pdf

[11] Jean-Yves Bouguet, "Pyramidal Implementation of the Lucas Kanade Feature Tracker Description of the algorithm", Intel Corporation, Microprocessor Research Labs OpenCV Documents, 1999.