GAIT ANALYSIS BY DIFFERENT TECHNIQUES

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Abstract
Gait analysis is used in clinical evaluation of musculoskeletal system, design and assessment of prosthesis (especially for lower limbs), in the process of rehabilitation after injury and in biometrics. This paper reviews the general methodologies involved in kinematic gait analysis right from acquisition of data to processing and interpretation of meaningful results. The major components of kinematic gait analysis are: acquisition of data by cameras or instruments like accelerometers, electrogoniometer followed by processing and examination, measurement of general gait parameters, and electromyography (EMG).

Keywords:
Gait Analysis, Prosthesis, Biometrics, Kinematics.

1. INTRODUCTION

Gait analysis is the study of locomotion (walking pattern) of a human or an animal from data recorded through instruments like accelerometers, goniometers, cameras, pressure sensors etc. [Vasilios K et.al.]. Gait analysis includes both kinetic and kinematic analysis.

Kinetic analysis involves the study of forces which causes the movement or locomotion with the help of pressure sensors and force plates. Physicians may prefer their patients to undergo clinical gait analysis instead of radiographic imaging, as gait analysis can be used to study the progression of neuromuscular diseases. Pathological conditions can be classified and differentiated from the information drawn from gait analysis.

Kinematic analysis involves the measurement of geometry of movement without considering the force that causes the movements. Cameras, accelerometers, goniometers are used for acquiring data for kinematic analysis. Majority of kinematic evaluations are performed using video graphic or optoelectronic systems consisting of integrated hardware and software components [Nikolaos V et.al].

Several techniques have been developed over the years for gait analysis. They differ in the methodologies used for data acquisition. Some of them are large, expensive, time consuming (for acquiring and processing of data), requires trained personnel to operate and interpret the results. Some other techniques that are applicable in routine clinical practice are inexpensive and do not require technically trained personnel to operate and maintain it. This paper reviews the techniques developed for gait analysis, their merits and demerits and future uses.

2. DIRECT MEASUREMENT TECHNIQUES

Direct measurement technique deals with sensors that are attached to the dynamic portion of the body. Devices like goniometer (mechanical and electrical), accelerometers are used as shown in figure.1.

The advantages of this instrument are low cost and low complexity. These instruments are mainly used in gait analysis on lean patients than on muscular patients as there will be an angular change due to skin and muscle movement [Davrondzhon G et.al.]. The first type of electro-goniometer was first developed by Johnson and smidt (1969). The first light electro-goniometer was first devised by Mitchelson (1977) which is used to measure the limb angle using light sensing devices. Gore (1980) conducted a series of experiments to monitor movement of hip joint during gait. He used tri-axial electro-goniometer to measure the hip movement in both the left and the right leg [Currie, G D et.al]. Attaching electro-goniometer to the subject is a time killing process as the potentiometer should be attached properly to the limb segments and the center of rotation precisely over the joints [Mallye, M et.al].

Fig 1.Measurement of Elbow Angle Using Electro-goniometer
2.1 ACCELEROMETER

Accelerometers are electromechanical devices for measuring acceleration forces and are a good choice for evaluating the human body movement and balance. It is a non-invasive and portable method that can accurately measure simple parameters of gait such as stride time, stride symmetry and speed. The accelerometers encompass a mechanical sensing element. So the obtained mechanical signal is converted to electrical domain. The accelerometer sensors are also used in biometric gait authentication. It is done in two methods: visual-based gait recognition and sensor-based gait recognition. The accelerometer sensors are placed in hip, waist, chest regions or in hands [Manal, K., et al.]. G. Currie et al., performed a new technique for the evaluation of temporal and spatial parameters of gait using accelerometers. He used three accelerometers in orthogonal directions as an instrument which records the acceleration of the centre of gravity in the three directions as the subject walks [Südhoff, I., et al.].

3. INDIRECT MEASUREMENT TECHNIQUES

Indirect measurement technique (also known as non-contact or imaging technique) involves video recording of the walking subject. CCD cameras are used for indirect measurement techniques. Apart from the information about the patient walking pattern the recorded video has additional redundant information about the background, noise etc. Markers are used to track the movement of the subject [Benedetti, M.G., et al.]. Markers are placed on well-defined anatomical landmarks to trace the image of the dynamic portion effectively.

The markers used in the marker based system can be again classified into active markers and passive markers. An active marker emits light on its own. Light emitting diode (LED) comes under active markers. Passive markers cannot produce light on their own. They are coated with reflective material to reflect the light produced by light source placed near the camera used for recording. The light is reflected directly along its line of incidence [Benoit, D.L., et al., Lucchetti, L., et al.,]. For both active and passive marker system to acquire the required data from the video, certain software techniques have been developed. It involves 2D and 3D reconstruction of images. Presently experts are working with marker-less gait analysis systems. The subjects need not wear markers on their body. Specialized image processing tools have been created and utilized for obtaining the required information from the image without using markers. Marker-less systems were developed in order to reduce the discomfort caused in patients while using markers. Markers also increase the complexity and cost of the recording system. The features acquired during gait analysis can be divided into static features and dynamic features. Static features do not change with the variation of mental state. Features like height of the person, length of leg comes under static features. Dynamic features describe the motion of human. Trajectories of positions of knee joints and ankle joints are extracted as dynamic features [Lucchetti, L., et al.].

4. GAIT ANALYSIS USING ACTIVE MARKERS

Nissan Kunju et al. used Labview for processing the image obtained using active markers. The LEDs (Light Emitting Diodes) are placed on the corresponding anatomical positions. The subject is made to walk in a complete dark environment and video recording is done. A template for the marker used in the recording is created. Lab view uses template matching algorithm to find the locations of markers in a given image slice or video as shown in figure 2. Then the corresponding angles are calculated using the co-ordinates of markers. Nissan Kunju et al. also measured the angles using electro-goniometers. The results obtained in both the methods are compared. This method can be used for full body kinematics study or study of a specific limb with a little or no change. The parameters like frame rates and number of frames to be captured should be modified depending upon the dynamics of the joint under study [Reinschmidt, C., et al.].
5. MARKER-LESS TECHNIQUES

Markers attached to anatomical locations can change the gait patterns and also cause pain (intra cortical bone pins). To solve these problems marker-less systems are being used in modern gait analysis. Acquiring details from the video in marker-less techniques can be done manually or by specialized software. David H. Sutherland and John L. Hagy used manual method for gait analysis. In this method the video of the walking subject was acquired from cameras placed orthogonally (at the sides and front) as shown in figure 3. A special projector is then used to determine the measurements the instrument projects the film image of the subject onto a viewer and it has superimposed horizontal and vertical wires which can be adjusted for determining the co-ordinates of anatomical landmarks as shown in figure 4. The parameters like knee angle, hip angle can be calculated using triangulation. J. Saboune and F. Charpillet used a marker-less technique which involves simulation of a model and comparing it with the video of a walking human.

6. FUTURE OF GAIT ANALYSIS

The following ideas can be implemented to take the gait analysis to the next level. Real time gait analysis systems should be made to reduce the time involved in processing of information into a meaningful result.

- Different types of locomotion tasks should be developed and used instead of regular tasks in order to analyze different pathologies. For example, knee pathologies can be studied better using tasks like stair ascent or descent than normal walking alone.
- The link between the scientific investigations of gait and the clinical application of results should be strengthened in order to increase the usage of gait analysis in rehabilitation medicine.
- The gait analysis tools or methodologies which provide appropriate/sensitive measures for clinical population should be identified and used widely.

7. CONCLUSION

Gait analysis is useful in clinical applications for diagnosis of neuromuscular and musculoskeletal diseases involves creation of model for comparing with real time image sand data. The development of appropriate models facilitates a deeper understanding of the behavior of the musculoskeletal system and allows predictions to be made regarding its response to various perturbations without the need for live animal experiments.

8. REFERENCE

[5]. Malcolm Ellis (Rheumatism Research Centre, University of Leeds), Adrian Howe (MIE Medical Research LTD.) - A Clinical Gait Analysis Systems.
[7]. Nissan Kunju, Neellesh Kumar, Dinesh Pankaj, Aseem Dhawan, Dr Amod Kumar,(2004). Central, EMG Signal Analysis for Identifying Walking Patterns of Normal Healthy Individuals - Scientific Instruments Organisation (CSIO), Chandigarh.


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