Computer Vision Technology on Biomechanical Diagnosis

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Abstract - Biomechanical diagnosis systems consists of movement capture equipment based on infrared cameras that record parameters as speed, acceleration, position and angle of the movement of the body to diagnose pathologies and progresses in medical treatments on locomotive human system.

The diagnosis system that we are interested in is the study of the joint dynamic segments. Today, studies of statics and dynamics movements use technologies of diagnosis as gait laboratories or posturography equipment.

These diagnostic systems are valuable in the treatment of pathologies of mobility. His need is recognized by the specialists but the costs of this technology do not allow his use in most of the hospitals, inducing the doctors to realize qualitative diagnoses.

The research project consists of the design of low cost biomechanical diagnosis equipment, based on routines of artificial vision, which allows realizing motion capture, measurements and record of the biomechanical movements as a technical support for the diagnosis of pathologies.

The equipment allows medical staff, by means of routines of artificial vision, to register the movements of the patient and his later analysis with free software routines. The equipment and the software implement the most used diagnosis routines with the possibility of upgrade in several routines of medical diagnosis for pathologies of movement.

Keywords: Biomechanical diagnosis systems, artificial vision, medical diagnosis for pathologies of movement

1 Introduction

The traditional methods for biomechanical pathologies diagnosis consist on equipment with tracker, infrared cameras and software for processing measurements of position, speed, accelerations and forces.

Nevertheless, today these technologies are not extensively used because his high cost, even if his benefits are known in the correct diagnosis of pathologies of movement. For this reason the doctors do the diagnosis with static systems, as medical images and with qualitative methods; there are the traditional methods, but it does not allow a quantitative examination that diminishes the possibility of a mistaken diagnosis.

The research project consists of the implementation of equipment based on artificial vision to obtain the necessary measurements in the protocols of biomechanical diagnosis, by means of the use of routines of free software as OPENCV, allowing the doctors to use the tool for diagnosis of pathologies of movement, with accessible cost and easy technological manipulation by medical staff [1,2].

2 Methodology

Equipment designs initiates with the establishment of measurement routines for the biomechanical diagnosis, according the medical bibliography and medical protocol, in order to determine the hardware and software platform design. The first routines are limited to the measurement of the positions, speeds and accelerations of the corporal joints.

Once, the initial development finished, proceeds with the software implementation of routines designed for protocols in the medical area, completing the final equipment to be proved in institutions in rehabilitation areas.

After a study of a wide bibliography, we conclude that are some measurement protocols that want to be probed: test of motion control, limits of stability, changes of rhythmic weight, push-up, change of position and gait tests; that has decided, are the routines that allow giving a diagnosis to pathologies of mobility. The unit can be used also on Tinetti test to evaluate 16 items and to value the static and dynamic body balance. It allows classifying in a more efficient and quantiative way 3 gradients: normal, adapted and abnormal. In the stand up and walk test, the proposed unit allows measuring the time delay in the movement, evaluating the risk to falls. In the Test of Romberg the patient is placed in two foot standing, with the feet together and the loss of body balance is evaluated in a certain time. With the system of artificial vision we can predict the time before fall down with the measurement of the body inclination. The test of sensory organization can be implemented adding measurements before to the body fall down.

An important additional factor is the measurement of the evolution in the medical treatments. This is now possible with the unit developed. It uses the quantitative measurement in contrast to the traditional procedures that use systems with qualitative measurement.
2.1 Systems for somatosensory, visual and vestibular stimulus.

Additional to the artificial vision system for the diagnosis, it is necessary to design the systems for sensory stimulus. It consists of dynamic platforms and systems for visual display.

As additional innovation, Virtual Reality system is used for visual stimulus. This allows more real stimulus and consequently the response of the patient is more effective.

![Fig 1. Gait laboratory.](image)

2.2 Traditional systems for biomechanical measurement.

Gait laboratory is a traditional measurement system that consists of infrared tracking systems for the diagnosis and treatment of problems on the locomotive system and neuromuscular system (Figure 1.)

The system allows the simultaneous compilation of data and body images in three dimensions [7], and after processing the recorded information, the results are concluded in clinical graphic videos and technical medical reports, with the status information of the movements and his deviations of the ideal offset. The obtained information facilitates the recognition of the principal functional problems and his relation with the cause that generates them; those are elements of supreme importance on suitable planning of the treatment. [6]

The studies allow identifying all the deviations of the normal gait, in such a way, in the future the patient is submitted to a minor valuation of surgeries (figure 2)

![Fig 2. Gait laboratory. Strathclyde university (Glasgow)](image)

The system made with artificial vision software (Figure 3) reconstructs the joint movement in the same way as gait laboratory do. The system use digital cameras as sensor elements and predetermined dot color as marker.

The acquired information is stored for later analysis and comparison with the traditional diagnosis systems. Statistical ANOVA analysis is used for comparison of averages for both systems: the traditional systems and the proposed system.

![Fig 3. Biomechanical diagnostic lab for the research](image)

System with digital cameras have the same efficiency as the system with six infrared cameras, the reconstruction is possible in 3D in both systems.

2.3 Diagnosis Routines Development

2.3.1 Motion control test

The control motion test determines the skill of the patient to recover on external perturbation. It is necessary to design a balance platform to change the gravity center of the patient and know his response. With the software of artificial vision we can measure the speed of reaction and the displacements of body, as well as the strategies of recovery of the body balance (figure 4, 5).
2.3.2 Test: Limit of Stability

Test of limits of stability determines the maximum distance that a person can displace his center of gravity. The quantitative measurements are response time, speed of the movement, maximum inclination and directional control. This protocol is diagnosed by means of measurements of displacement of marker [4] using artificial vision program (figure 6).

2.3.3 Rhythmic Gait Change test

The test of rhythmic changes of weight, establishes the skill to move rhythmically his center of gravity. This measurement can be realized by markers and artificial vision [8,9] located in several parts of the body and be able to determine the changes of position and inclinations as part of the response of the body to the test. (Figure 7)

2.3.4 Knee Flexion

The knee flexion test measures the stress supported by the knees and ankles, a situation that does not happen in full flexion, where the weight is supported by the all skeletal system [5]. The artificial vision system would determine the balance of the weight carried per foot depending on the level of inclination of the body position (Figure 8).

2.3.5 Test Of Change OF Position

The test of change of position (stand up and sit), measures the skill of changing the center of gravity from position with base support to extension position. The measurements that can do by the proposed unit are the speed of the change of position and symmetry in the movements of the feet (Figure 9).

2.3.6 One Side Position Test

The test of one side position (figure 9) is realized with closed and open eyes to determine if the problem comes from visual or vestibular system. The proposed unit might measure the parameters necessary for this diagnosis. [5]
2.3.7 Gait Test

The gait test determines the symmetry and the distance in the steps in a normal gait. As the previous tests, the system with artificial vision measures the positions, speeds and symmetry of body during the test. [5]

![Gait test (Neurocom).](image)

2.4 Artificial Vision System and Virtual Reality

The artificial vision software used was OPENCV in Linux with QT. The routines identify colors that we use as marker and measure the angles, positions and his speeds. [3] (figure 11)

![Biomechanics diagnosis system developed for the research](image)

2.5 Software routines for joint angle determination

```c
float ar2=sqrt(pow((vax2[2]-vax2[0]),2) + pow((vay2[0]),2));
float br2=sqrt(pow((vax2[2]-vax2[1]),2) + pow((vay2[1]),2));
float cr2=sqrt(pow((vax2[1]-vax2[0]),2) + pow((vay2[0]),2));
float rad2=acos((pow(br2,2)+pow(cr2,2)-pow(ar2,2))/(2*br2*cr2));
int grados=360-(rad2*180/3.141592654);
```

![Block diagram design system](image)

Software routines for marker position determination

```c
M frame=cvQueryFrame(cam1);
frame2=cvQueryFrame(cam2);
cvSplit(frame,b,g,r,NULL);
cvSplit(frame2,b2,g2,r2,NULL);
cvSub(b,r,g1);
cvSub(b,g,g2);
cvThreshold(g1,g1,0,255,CV_THRESH_OTSU);
cvThreshold(g2,g2,0,255,CV_THRESH_OTSU);
cvAnd(g1,g2,G);
cvSub(b2,r2,g12);
cvSub(b2,g2,g22);
cvThreshold(g12,g12,0,255,CV_THRESH_OTSU);
cvThreshold(g22,g22,0,255,CV_THRESH_OTSU);
```
3 Conclusions

The system based on artificial vision allows to realize quantitative measurements in biomechanics test, the cost is low because the use of digital cameras and free software. (Figure 13)

The images reproduce the joint movements with the same accuracy as the images taken by infrared cameras. The marker can be discriminated in a simple way by colors.

The cost is very low on comparison with the traditional diagnosis units. Since limitation does not exist in the number of cameras, review is possible in anybody position on real-time. The software allows, by means of routines of artificial vision, to visualize the movement in panoramic form in angles of 360x360.

The system has same functionality of the traditional systems.

4 References


