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Motion Capture vs traditional medical examinations

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Abstract: This article present the Reader with a novel method of medical examinations that uses state of the art utilities, namely motion capturing as a basis to replace traditional methods. In this paper, the authors compare two methods that yield the same results although the data are obtained differently. The goal of this presentation is to indicate the pressing need to modernize these examinations, for which we recommend the motion capture based medical examination that we use on our faculty. In the end we hope to convince the Reader that though traditional methods result in more-or-less the same set of data, the processing and analysis cost is much higher than in MoCap-based examinations.

Key words: motion capture, medical examination

1 Introduction

This paper is a comparative presentation of two different medical examination method. On the one hand, it serves as a pointer for the Reader who wishes to get up-to-date information on medical examination methods and future research areas. However on the other hand this document presents the Reader with the challenges that are overcome by using motion capture based medical examinations thus trying to prove the worth of such methods.

Throughout the paper we are going to reference our projects that were created to further investigate the possibilities that lie in the field of using motion capture in a medical setting.

The coarse structure of this paper can be summarized as follows. First, we present the two methods, one-by-one with briefly stating their advantages and disadvantages, the set of context each were used during our research. The Reader is going to get a vague information about the possibilities in each method.

The next section goes into further details about our target motion capturing platform, the specific questions that arise when working with an existing hardware and software component that was created particularly with the medical field in mind.

The final section presents a summary of experience gained in working with the two methods along with a conclusion.

2 Presenting the two methods

2.1 The manual method

Our first approach was a manual one. In this case we used a flexible, shape-retaining ruler, which was created particularly for medical purposes. This utility retains its shape if bent in any way, thus allowing for the curvature of the spinal column to be registered.

The utility is known in medical sciences for its versatility in shape registering (Rose S. J. et al). Analysis of the spinal column was made more convenient by this device.

The next step after registering the curvature was to record it in a traditional paper-based form, thus the doctors leading the research copied it into A3-sized sheets. Curves recorded from one patient went on to the same page, so that further filing be possible. Curves from different postures of a patient were marked with different colour, but otherwise they were put onto the same page.

The analysis part of the manual method used image-processing solutions, as the curves were digitized with the help of a normal digital camera. Filtering the different colours pose no problems provided they are dominant enough to be separated from the background.

This way it became possible for us to gain a 2-dimensional overview of the spinal curvature. There seems to be no chance of reconstructing the 3-dimensional structure of the spine. In certain applications this is not needed, as most physicians' decisions are based on certain angles of vertebrae and a projection is more than sufficient for this information to show through.

The manual method arose some questions that might with a certain degree of playfulness be called a 'calibration problem'. When the curves were copied to the page, their orientation, the root of the curve and the relative position between postures was in most cases lost. The different postures thus are only vaguely connected, in a number of situations it was impossible to deduce information from one to the other.

Besides these problems, that are – with a certain amount of time given up to actually measuring and copying the origin and orientation of the spine and the change of these parameters between postures – somewhat solvable matters, there is another, more dominantly interfering with the measurements. There was no information about the underlying skeletal and muscular structure, the vertebrae.

It seems highly inconvenient for a physician or a general practitioner to draw figures that have a detail level that rivals with architectural blueprints and illustrate in every curve the position of the vertebrae, not to mention their orientations.

In an average set of examinations, two to three postures were investigated, in which the patient was moved through the full forward and backward motion. Measuring, then noting each vertebra is very time consuming and might distract the doctor's attention from the patient, who in turn would show discontent with the examination.

2.2 The Motion Capture method

Motion Capturing is a widespread method for registering human motion – in the film industry and actually in entertainment in general. It is not very common sight on the other hand in GP's offices, although it is quite well known, that the whole idea of motion capture has come into life in medical settings.

Nowadays the term 'motion capturing' usually is associated with the over-the-edge special effects movies. Our project group set out to make motion capturing in medical environments an option. We want to show with this paper that motion capturing is in fact a notable opponent – if not a better method – of traditional examination methods.

We possess a Zebris Medizientechnik Gmbh ultrasonic motion capturing device. This instrument is one of those few that were manufactured with the physician in mind. The company claims that their product is primarily a medical device that is ideal for gait analysis, spinal analysis, force distribution analysis in combination with the aforementioned gait analysis, and combined EMG analysis.

The utility is an ultrasonic device, thus has its limitations. It uses wires to transfer signal from the markers to the central unit. This way, the movement is somewhat restricted by cable length. In general, the unit allows for a limited number of markers to be processed, which in our case wouldn't exceed 8 markers at a time anyway. It is not within the boundaries of this paper to go into details of integrating this device with an optical mocap unit to gain a virtually unlimited number of markers that can be processed in real-time be it actual marker or a certain anatomical feature of the human body, but one of our promising project goals include this sensor fusion.

Measurements are supported by the software that came packaged with the unit. There are different modes for investigating different features – examining spinal mobility is one module of particular interest. Using the software we tried to create a set of data that is very similar to that of the manual method.

The principle of the measurement is that small microphones are attached to the body. There are three external ultrasonic transmitters, that are grouped together to form a frame with known position and orientation. From the signal of one microphone, the distance from the transmitters can be calculated and knowing all three data and the absolute position of the transmitter frame, the relative position of the microphone can be calculated.

Using special marker frames containing three-microphones, the orientation is also obtained for the frame (six degrees of freedom).

With the patient wearing the markers, the only thing they have to do is move in the directions the software module indicates. These movements have been created in a way that the most of the information is obtained from a single exercise with keeping the extent and number of movements at a minimum.

The unit records the motion in its entirety, so both spatial and temporal dimensions are preserved, and in any future time reconstructable. The data is also visualized in a primitive 3D view in which the doctor can follow the motion and immediately see if there is anything out of the ordinary.

Processing the data is pretty straightforward, as the motion can be analyzed through time. Not only the posture information is present in the data, but a rich set of auxiliary information, such as angular velocities, angular acceleration, or normal velocities and accelerations are also accessible.

With the physician in mind, the software is wired with a feature-rich report generating submodule, which is crucial to get readable and understandable information out of the raw motion data that is the output of the device.

The reporting module of the software is capable of illustrating the posture of the patient in a way that is very similar to the result of the manual method. However the normal and disorderly ranges are also noted on the report automatically thus everything needed for making decisions is absolutely just at a glance.

Another handy feature, that is impossible with the manual method is motion analysis, that uses the aforementioned angular velocities in a polar coordinate system to determine if there was any vertebra not moving in an even manner throughout the whole motion in flexion/extension. This is very useful information because identifying painful movements, thus recognizing cramped motion range is key to diagnosing musculoskeletal disorders.

Of course there is a cost for this accuracy and wealth of information and as every method, motion capturing has its own disadvantages. One is the limited range of measurement that is caused by using cables. The other is a slightly increased overall measurement time. While a manual measurement is done in average under 2 minutes, a five minute measurement is what we can expect from the motion capture method, most of which is taken up by placement of the markers and achieving a relatively noise-free and valid motion.

The motion capture method is on the other hand ideal for a thorough investigation that is to be achieved in a minimal frame of time, for example in a central medical examination facility that specializes in measuring patients who were sent in by GP's for a diagnosis.

2.3 A comparison of the methods

	Manual	Motion Capture
Time of measurement	1-2min	5-10min
Setup	None required	Required once
Ease of use	Very easy	Requires practice
Obtainable information	Very limited	Rich set of information
Reconstructability of motion	No	Yes
Cost of utility	Low	High
Extendibility	None	High
Data processing cost	High	Low
Data validation	Manual	Automatic
Reusability in other areas	Low	High
Number of anatomical points	N/A	8-10

Table 1. Comparison of the methods

3 The CMS-HS ultrasonic motion capture device

3.1 Features

The device used in our laboratory is an ultrasonic device. It provides for a sub millimeter resolution with a maximum of 100Hz sampling rate. This proved to be more than sufficient for medical purposes, all the more so compared to the accuracy of traditional palpation based examinations.

The device consists of a central unit, either one, or two transmitters and a number of markers. The whole device is then attached to a simple PC computer or laptop that in the end collects and stores the data.

Processing is also done on the PC.

At the present time, our device can accommodate up to 12 digital markers, which is enough to examine a fraction of the spinal column. In our case the lumbar section of the spine was examined in more detail. The markers can also be grouped together to form triplets which are capable to determine the orientations in addition to the position.

The unit can also handle analogous sources as markers, so integration with a force-pad is seamless. Sources such as EMG markers are also supported. This way a more complex analysis of the musculoskeletal system can be achieved and even muscle activity can be measured.

3.2 Setup and calibration

Setting up the device is fairly easy. Only the inclination angle of the transmitter head is to be measured and entered via a graphical user interface. Setting up a two device situation is one notch harder, as the positions and orientations of the two transmitters are to be noted and the user is also warned to set the two transmitters up in way that they complement each other. So with one head facing west, the other should face east.

Calibration is done from the given software module for the particular examination types. It consists of an automatic leveling of the signals to a given state, that would mean the starting position from then on. With exercises not requiring absolute positions, but only relative motion and posture information this is sufficient.

With examinations requiring absolute positions, the appropriate software module leads the user through a step-by-step calibration process. This includes marking the ground plane and the initial anatomical points that would create a frame for the human body from which to reference motion.

Calibration might be necessary from exercise to exercise and the software might indicate that there is a need to resynchronize (calibrate) the signals.

3.3 Pointer

The unit is extendible with a special device, that is called a pointer. This utility allows the CMS-HS a functionality that closest complement the manual method. The pointer is used to denote a 3-dimensional curve. The user has only to move the tip of the pointer along the surface and the device records the curve with a given resolution.

The pointer was created to speed up spinal analysis and recording of anatomical points with a limited number of markers.

4 Conclusions

Through our experiences we found the manual method to be the cheapest and most flexible one, with no pun intended. It is a fast and efficient way to record posture information of a huge number of patients. However analysis of these data is very challenging and an incomplete set of information is all we can obtain from the results.

The manual method proved to be the convenient method for measuring a large number of patients in a limited amount of time. The method on the other hand was full of possibilities for error and it drew a lot of negative consequences regarding analysis and consistency.

The motion capture method was slightly less efficient as it took more time to complete a set of examinations. We found it recommendable in a situation where a limited number of patients should be examined quite thoroughly. The method also provides for an outstanding analysis. The data obtained is accurate and reconstructable and contains both 3-dimensional and temporal information.

While the manual method would prove to be ideal in a GP’s office frame of mind, the motion capture method is ideal in a central medical examination facility settings.

References

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