Wearable Computers for Quantification for Lower Back Disorders

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**Concept of Operations**

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for

Wearable Computers for Quantification of Lower Back Disorders

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# Executive Summary

Low back disorders (LBD) are a very common disorder where the muscles and the bones of the back are involved. It affects about 40% of the people at some point in their lives, which results in a substantial cost to society in terms of healing the patient. Although society knows about this common problem, in general, there has been little to no progress in the control of LBDs. This is because many assessment tools of low back disorders are subjective. The current technology would only facilitate the tracking of the recovery and help document the appropriateness of treatments.

To improve LBD treatment strategies, it is desired to quantify and track the changes within the lower back area. Since the quantification of Low Back Disorder has been regarded as a key to functional restoration, our team seeks to develop a system of wearable electronics that will be used to test the severity of lower back issues and quantify the results. This will provide measurements to aid the physician’s decision to proceed with or decline surgery. This is important because without a quantitative measure of low back status, the identification of back pain is difficult. In addition, this may provide a benchmark of when the patient is ready to return to a job without increasing the risk of worsening the disorder.

To approach this problem, our team will use two sets of very common sensors, which are motion sensors and physical sensors. For our motion sensors, we will use the Kinect to study the movement of the patient and analyze it. However, this approach has its drawbacks. For instance, motion sensors cannot detect small changes in the body while the patient is moving, and this will require an accurate measure. That is why we will use the physical sensor to overcome the limitations of the motion sensor, and complement each other.

# Introduction

The difference between a lower back disorder requiring surgical intervention versus pain management is largely subjective. Our team seeks to develop a system of wearable electronics that will be used to test the severity of lower back issues and quantify the results. This will provide measurements to aid the physician’s decision to proceed with or decline surgery.

## Background

There is currently not a similar system available. This is advantageous because it will be unique, but also is challenging in that the accuracy of the test will be more difficult to prove. The medical test itself was developed by leading researchers and has proven to be up to 94 percent accurate in correctly identifying a patient with a lower back disorder compared to a control patient. The system of electronics will be developed with the aid of Dr. Jafari and the Texas A&M Embedded Systems Processes Laboratory.

## Overview

The system will consist of wearable, motion sensing electronics working in tandem with a Microsoft Kinect. The various sensors will work together to help reduce error and provide a high level of accuracy. This is necessary to maintain the integrity of the lower back test. The test will quantify the issues found with the lower back and assist physicians in making the correct call on whether or not to move forward with surgery.

## Referenced Documents and Standards

1. "The Quantification of Low Back Disorder Using Motion Measures." Marras, William S., Sue A. Ferguson, Purnendu Gupta, Smarajit Bose, Mohamad Parnianpour, Jung-Yong Kim, and Robert R. Crowell.
2. “Home-based Senior Fitness Test Measurement System Using Collaborative Inertial and Depth Sensors.” Chen Chen, Kui Liu, Roozbeh Jafari, and Nasser Kehtarnavaz.

# Operating Concept

## Scope

Our team will try to quantify the severity of the low back disorder to aid the physician’s decision to proceed with a surgery or not by using wearable computers.

To make this possible, we will require to do a set of tasks, which include the use of motion sensors (Kinect) and physical sensor (gyroscope and accelerometer) to track the lower back area, and use it as an input to measure the angle of the torso to use it as a method of diagnosis.

This project will have a timeline in which we will build a prototype in the beginning of March, and have our final design in the beginning of December.

## Operational Description and Constraints

We will be striving to create an affordable wearable device that will be used for common clinical use with potential extension into home usage. This device will allow physicians to quantify different levels of low back disorder in order to give more accurate diagnosis to patients. However, this device must also be non-intrusive and user-friendly such that it is not intimidating and easy to put on and use.

## System Description

Our system will be composed of five main areas. First, we will have our wearable device which will include an array of physical and motion detection sensors. These will allow us to collect a variety of different data which will help quantify low back disorder and correct for errors in other sensor readings. This will then feed into a synchronizing unit which will collect all of the data and control the timing of our system. This will then feed into a control block which will analyze it in order to start quantifying the data and correct for any errors in the sensor readings. This will then feed into a user interface for the physician to receive the analysis and help with their diagnosis of Low Back Disorder.

Block Diagram.png

Figure 1. Block Diagram of System Level Design

## Modes of Operations

As mentioned previously, our wearable device will be meant mostly for clinical uses. As a result, it will be worn indoors at usually room temperature while the patient wears it and performs a series of tests to help quantify their level of Low Back Disorder. This will mostly include non-intensive motions such as rotating, walking, sitting, and standing. As a result, our device does not need to be particularly durable outside of being able to potentially drop it without damaging it. In addition, there is no immediate need to make it withstand harsh usage such as the need to make it waterproof or shock resistant.

## Users

Our project will be mostly designed for a physician, which will require at least some degree of technicality for it to install it, and use it. This will benefit all people that suffer from low back disorders since it will help the physician to make an objective decision instead of a subjective, which depends from the experience of the physician itself.

## Support

There is currently no plans to provide extensive customer support such as an easily reachable tech support outside of calling the manufacturers for more potential device information. However, there will be a user manual to help provide basic instruction for setting up the device. In addition, there will be first-hand support and training when the device is initially bought in order to provide physicians with all of the training they require to get started with using the device.

# Scenario(s)

## Clinic Based Scenario

Our main use case will be inside of clinics with readily available physicians who wish to perform a set of tests to quantify the severity of Low Back Disorder. The patient will be instructed to perform a series of non-intensive tests such as walking while wearing our device. Data is collected by the sensors in the device and analyzed, at which point, the collected information is made available to the physician to allow him to give a more accurate diagnosis to the patient. All of the tests, data, and the diagnosis of the patient that are done will comply with any policies or restraints provided in such clinic interactions with physicians.

# Analysis

## Summary of Proposed Improvements

This system will greatly improve the diagnostic capability of medical personnel in attempts to determine lower back disorders. Due to the current subjective system in diagnosing lower back disorders versus natural pain, it is difficult to produce consistent data in order to backup numerical evidence of a disorder. By implementing this system, doctors of medicine and physical therapy will have a vastly improved, quantitative, and objective tool to determine if surgery is needed to correct a disorder.

## Disadvantages and Limitations

## The primary disadvantage of this system is the lack of proper test equipment in order to verify the data we are receiving. The accuracy of our measurements directly correlates with how successful the data gathering of our sensors is. As nothing like this has been tried before, there are no data points we can check ourselves against. However, discussed next in the “Alternatives” section, are motion capture systems that could produce the data simply to verify our accuracy. Another limitation is that this device is being built for data gathering by engineers. Though medical oriented papers and personnel will be referenced, we do not have the extensive background knowledge to limit the exact data points we would like to see. Therefore a broader scope will be necessary, with further refinement implemented in future experimentation by doctors associated with lower back disorders.

## Alternatives

Currently there exists no established system to gain the data we seek to use to quantify lower back disorders. There are several motion capture systems used in industries such as cinema and television that process massive amounts of movement data from points on actors and actresses. However, this system is extremely expensive and requires a high amount of technical expertise to analyze the data. The system we propose will significantly cut costs, and output the necessary data for the purpose of diagnosing whether a disorder exists or not.