A Functional ARM Movement Tracking and Monitoring System Using Electogoniometer

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ABSTRACT

This paper presents a new sensing system on magnetic linear encoder (MLE), in which the motion of an magnetic encoder on a code strip is converted into the limb joints goniometric data. This project evaluated a non invasive technique for estimating the carrying angle in full extension using a 3-dimensional digitizer. The angle data is essential data for identifying abnormal patterns and characterizing impairments, disabilities and handicaps. The knee angle is measured with an electrogoniometer, angle of knee is controlled by PIC16F877A microcontroller. Capsense technique is used to giving input to the microcontroller PIC16F877A, information are displayed using 16*2 LCD display.

Index terms: Magnetic Linear Encoder, Capsense technique.

I. INTRODUCTION

A major prerequisite for successful rehabilitation therapy after stroke is the understanding of the mechanisms underlying motor deficits common to these patients. Study in [1] shows how the damaged nervous system recovers or compensates for deficits in reaching, and correlated reaching deficits with the level of functional impairment. Smoothness is characteristic of coordinated human movements, and stroke patients movements seem to grow smoother with recovery and we use a robotic therapy device to analyse five different measures of movement smoothness in the hemi paretic arm of 31 patients recovering from stroke [2]. In order to enhance the recovery of upper extremity function during early stroke rehabilitation, functional electrical stimulation (FES) testing is required says [3]. Behavioural psychology has contributed much to the treatment of chronic pain, but has little or no place in the curriculum of physical rehabilitation schools or in the developments of treatments for movement disorders [4].

The general aim of this work is to determine the accuracy and feasibility of using an electrogoniometer for measuring simple joint movements. Electrogoniometers have utility for studying thumb movements during mobile phone use and may be used to evaluate other thumb-based input devices. In the existing system optical linear encoder (OLE) is used. Optical systems are used for gait and posture analysis of entire body, it is hardly used in functional assessment of a single joint or certain body part. There is a need to measure quality of movement to assess effectiveness of physical therapy interventions after stroke. Knee angular velocity may be a sensitive measure of change in performance of movement during functional activity, but not all the clinical centres have access to a movement analysis laboratory.

A. GONIOMETER:

A goniometer is an instrument that either measures an angle or allows an object to be rotated to a precise angular position. Goniometers are used for direction finding in signals intelligence applications for military and civil purposes.In crystallography goniometers are used for measuring angles between crystal faces.Also it is used to measure the angle of a human joint such as the elbow or knee.

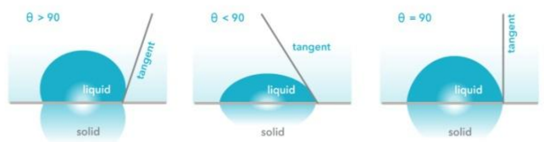
B. How to use a goniometer?

A goniometer is a tool used in medicine to measure the range of motion and is marked with degrees from 0-360 with two arms extending from this circle and one arm pivots freely while the other arm is mounted at the zero degree point. The goniometers centre is placed at the joint and both arms of the device are aligned using corresponding limbs and when the patient moves her limb the arms of the goniometer move as well with the new angle at the joint which is compared with the original angle readings to show the range of motion in degrees. The instrument of choice to measure contact angles and dynamic contact angles is Theta

.Both optical and force tensiometers enable static and dynamic contact angle measurement.

C. What is contact angle?

Contact angle θ, is a measure of the wetting of a solid by a liquid. It is defined geometrically as the angle formed by a liquid at the three phase boundary where a liquid, gas and solid intersect as shown below.



It can be seen from this figure that a low values of contact angle (θ) indicates that the liquid spreads, or wets well, while a high contact angle indicates poor wetting. If the angle θ is less than 90 degrees the liquid is said to wet the solid. If it is greater than 90 degrees it is said to be non-wetting. A zero contact angle represents complete wetting.

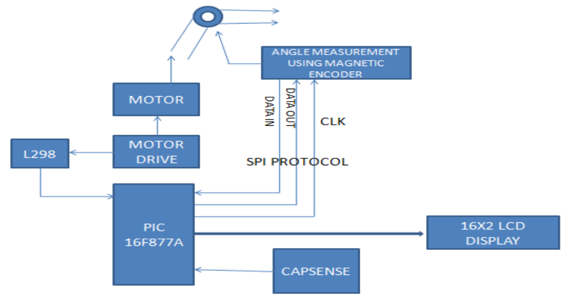
The measurement of a single static contact angle to characterize the interaction is no longer thought to be adequate. For any given solid/ liquid interaction there exists a range of contact angles which may be found. The value of static contact angles are found to depend on the recent history of the interaction. When the drop has recently expanded the angle is said to represent the 'advanced' contact angle. When the drop has recently contracted the angle is said to represent the 'receded' contact angle. These angles fall within a range with advanced angles approaching a maximum value and receded angles approaching a minimum value.

If the three phase (liquid/solid/vapour) boundary is in actual motion the angles produced are called Dynamic Angles and are referred to as 'advancing' and 'receding' angles. The difference between 'advanced' and 'advancing', 'receded' and 'receding' is that in the static case motion is incipient in the dynamic case motion is actual. Dynamic contact angles may be assayed at various rates of speed. Dynamic contact angles measured at low velocities should be equal to properly measured static angles. Contact angle can also be considered in terms of the thermodynamics of the materials involved. This analysis involves the interfacial free energies between the three phases and is given by:

$$\gamma_{LV} \cdot \cos\theta = \gamma_{SV} - \gamma_{SL}$$

where γ_{LV} ,γ_{SV} and γ_{SL} refer to the interfacial energies of the liquid/vapor, solid/vapor and solid/liquid interfaces.

II. BLOCK DIAGRAM:



A. CAPSENSE:

Capacitive sensing is a technique based on capacitive coupling that takes human body capacitance as input. The sensors detect anything that has conductive or has a dielectric different from that of air. Capacitive sensors sense many different variables by measuring capacitance. Variables like motion, humidity acceleration, position, proximity, fluid level, material composition.

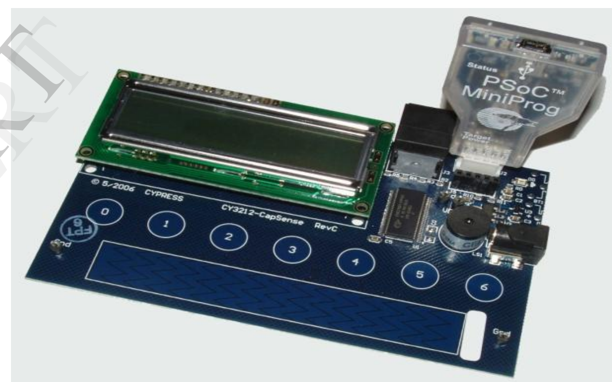


Fig1: CY3212-Capsense

B. MAGNETIC LINEAR ENCODER:

AS5040 is a contactless magnetic rotary encoder for accurate angular measurement over a full turn of 360◦.Inorder to measure the angle, only a simple two-pole magnet, rotating over the center of the chip is required. The magnet may be placed above or below the IC.The absolute angle measurement provider instant indication of the magnet's angular position with a resolution of 0.35◦=1024 positions per revolution. The digital data available is a serial bit stream and as a PWM signal. A user programmable incremental output is available, making the chip suitable for replacement of various optical encoders.

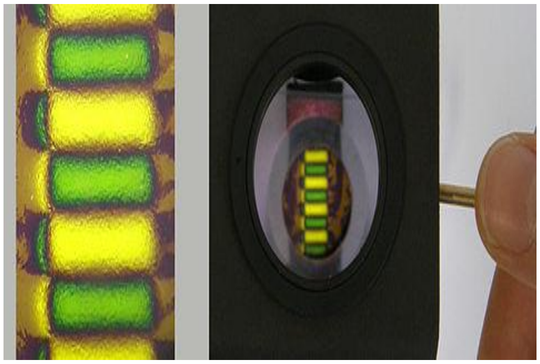


Fig2: Typical Linear Encoders.

A linear encoder is a sensor, transducer or readhead paired with a scale that encodes position. The sensor reads the scale in order to convert the encoded position into an analog or digital signal, which can then be decoded into position by a digital readout (DRO) or motion controller. The encoder can be either incremental or absolute. Motion can be determined by change in position over time. Linear encoder technologies include optical, magnetic, inductive, capacitive and eddy current. Optical technologies include shadow, self imaging and interferometric. Linear encoders are used in metrology instruments, motion systems and high precision machining tools ranging from digital calipers and coordinate measuring machines to stages, CNC Mills, manufacturing gantry tables and semiconductor steppers.

C. MECHANICAL DESIGN PROCESS:

Mechanical design process needs the support of Quality control program like "Inspection Geni".It is faster , more accurate and with fewer errors. Mechanical and quality control engineers enjoy increased automation in their quality control process. Manufacturing Reports and Ballooned Mechanical Design drawings are automatically created by Inspection Geni.

D. CIRCUIT DESIGN:

Capacitance is typically measured indirectly, by using it to control the frequency of an oscillator, or to vary the level of coupling (or attenuation) of an AC signal.The design of a simple capacitance meter is often based on a relaxation oscillator. The capacitance to be sensed forms a portion of the oscillator's RC circuit or LC circuit.. Basically the technique works by charging the unknown capacitance with a known current. (The equation of state for a capacitor is $i = C\, dv/dt$. This means that the capacitance equals the current divided by the rate of change of voltage across the capacitor.) The capacitance can be calculated by measuring the charging time required to reach the threshold voltage (of the relaxation oscillator), or equivalently, by measuring the oscillator's frequency. Both of these are proportional to the RC (or LC) time constant of the oscillator circuit.

The primary source of error in capacitance measurements is stray capacitance, which if not guarded against, may fluctuate between roughly 10 pF and 10 nF. The stray capacitance can be held relatively constant by shielding the (high impedance) capacitance signal and then connecting the shield to low impedance) ground reference. Also, to minimize the unwanted effects of stray capacitance, it is good practice to locate the sensing electronics as near the sensor electrodes as possible.

Another measurement technique is to apply a fixed-frequency AC-voltage signal across a capacitive divider. This consists of two capacitors in series, one of a known value and the other of an unknown value. An output signal is then taken from across one of the capacitors. The value of the unknown capacitor can be found from the ratio of capacitances, which equals the ratio of the output/input signal amplitudes, as could be measured by an AC voltmeter. More accurate instruments may use a capacitance bridge configuration, similar to a wheatstone bridge.. The capacitance bridge helps to compensate for any variability that may exist in the applied signal

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III. EXPERIMENTAL RESULTS:

The configuration of MLE-based system for this experiment is a single arm version with a wrist,elbow, and shoulder module. The objective is to testify the repeatability and reliability of the entire MLE-based motion capture analysis.

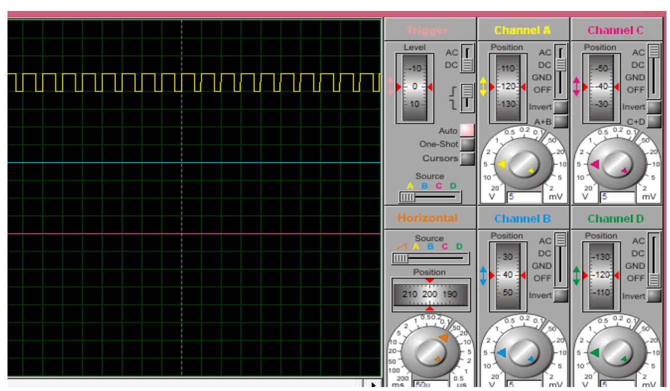

Fig3: Increasing Simulation output

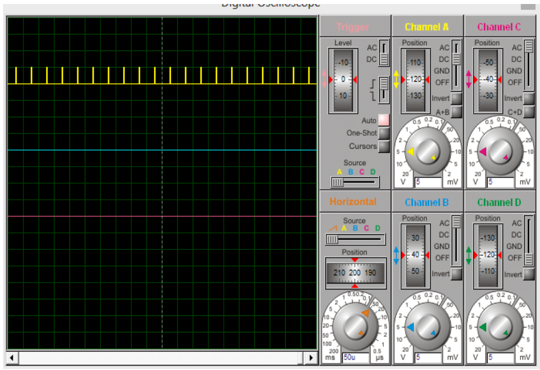

Fig4: Decreasing simulation outputs

IV. CONCLUSION:

The work is based on the design of the MLE system for the function of capturing human arm motion.The performance of MLE is comparable to that of the commercial motion capture systems.The sensor network is attached to the arm and evaluated for repeatability, reliability and sensing of the system. Analysis tests confirms our systems ability to perform and maintain its functions , with different biometric subjects.

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