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Analysis of Force in Human Muscle Using EMG in Hot Rolling Mill

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Abstract: The electromyography (EMG) is the measure of electrical activity produced by the muscles which is usually represented as a function of time. This electromyography can be used in various applications including identifying neuromuscular diseases, control signal for prosthetic devices, controlling machines, robots etc. The existing system commercial EMG-controlled devices are limited to rudimentary control capabilities of either discrete states (e.g. hand close/open), or one degree of freedom proportional control. The proposed system investigates the relationship between forearm electrical activity and forces exerted by the fingertips. This system is used to calculate the muscular force while lifting, pulling, pushing the object in Hot Rolling Mill with the help of electromyography. The load cell is used to calculate the force exerted by the fingertips of the human. The value of the force exerted is displayed by using the LCD. A threshold force value is fixed and it is compared with the actual force exerted by the human being. If the actual force exceeds the threshold value human beings will be affected in a way like sprain and bone rubbing etc., so an alarm is provided to indicate this situation to avoid the above mentioned accidents. The proposed system is simulated by using keil C and the simulated results are verified.

Keywords: ARM Processor, EMG, Load Cell, Data Acquisition System

1. Introduction

Estimate muscle forces based on an objective function within an optimization routine and minimizing muscle stress. Another solution uses electromyography in conjunction with an appropriate anatomical and muscle model to estimate the forces produced in each muscle. Since 'EMG-driven' models rely on measured muscle activity to estimate muscle force, these models implicitly account for a subject's individual activation patterns without the need to satisfy any constraints imposed by an objective function. This is important to investigate tissue loading throughout a wide range of tasks and contractile conditions, as the activation of muscle depends on the control task and can be quite different for the same joint angle and joint torque.

The primary muscles used to flex and extend the fingers reside within the forearm. Hence, many upper limb amputees retain control of these muscles, even though they are no longer attached to the fingers. These muscles can still contract, producing electrical activity that can be sensed at the surface of the skin. There is emerging evidence that the electrical activity of these remnant muscles can be used to control detailed movement of novel hand prostheses. Existing commercial hand prostheses are mostly limited to one function – opening and closing. The ability to control multiple functions of multiple fingers at one time is strongly desired by amputees.

The EMG of the remnant forearm muscles provides a possible manner to achieve this control.The lifting task started and finished with the individual in a static position without a load and consisted of lifting and lowering an object using both hands, while keeping the knees straight and executing the movement by flexing from the hip. For the purposes of analysis, the gesture was divided into four distinct phases:

(1) Bending forward without a load.
(2) Lifting the load.
(3) Bending forward with a load.
(4) Returning to the initial position.

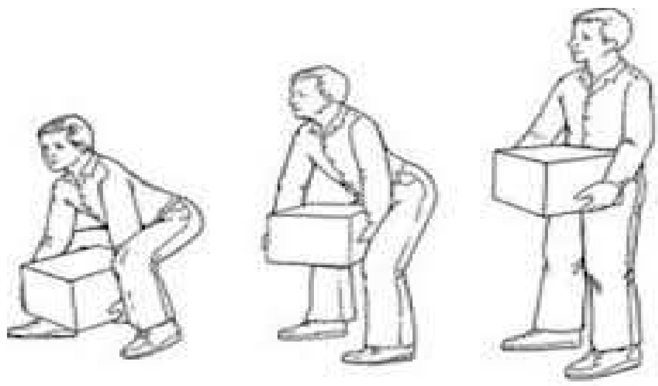

Figure 1. *Team Lifting.*

2. Literature Survey

Jefferson Fagundes Loss *et al* described a method of small degrees of flexion of the trunk can be considered a medium to high risk factor of injury, mainly when the angle of the forward inclination is greater than 15 degrees and is combined with lifting activities. As the task of lifting objects from the ground exposes spinal structures to muscular-skeletal overload it has been consistently investigated. In addition, epidemiological research associates lifting to the risk of developing lumbar back pain [1].

Jongsang Son *et al* presented a method of electromyography based real-time muscle force estimation system, which is available for a variety of potential applications, was introduced with electro goniometers. This system performing 3D motion analysis on ten subjects during sit-to-stand movement. EMG measurements were simultaneously performed on gastrocnemius medial is and tibial is anterior. This system, were compared with those from widely used commercially available off-line simulation software including a musculoskeletal model. Results showed that good correlation coefficients between muscle forces from the developed system and the off-line simulation were observed in gastrocnemius medial is ($r = 0.718$, $p < 0.01$) and tibialis anterior ($r = 0.821$, $p < 0.01$).

Kiguchi, K. *et al* explained a method to solve the problems related the dislocation of an artificial hip joint in Total Hip Arthroplasty (THA). In order to analyze the phenomenon of the artificial hip joint dislocation, a hip joint simulator has been developed. Although the hip joint motion and the hip joint contact force (the resultant muscle force around muscles of hip joint and the floor reaction force) during the daily life motion must be realized by the simulator, the resultant muscle force around hip joint cannot be prepared easily. In this method to estimate the resultant muscle force around hip joint based on EMG signals is proposed. Since the proposed estimation method requires only the measurement of EMG signals, the resultant muscle force can be estimated easily. The effectiveness of the proposed estimation method was evaluated by performing the experiments.

Rina Maiti *et al* explained a method to measure the peak isometric strength from 10 adult in Indian construction workers in eight different field-simulated postures. This peak-strength data in these FS postures were compared with symmetric postures. In symmetric postures, the vertical load positions were kept the same as FS postures and the points of force exertion were fixed at 40 cm distance in front of the subject. From both symmetric and FS static strength data, it was shown that the maximum peak strength occurred at medium vertical height level and decreased with both increase and decrease of the vertical height level. The maximum and minimum peak strengths were obtained in different FS postures as and respectively. It was observed that the lifted weight in the field was 12.0 kg, which corresponds to 54.54% and 137.3% of these maximum and minimum peak-strength values.

Julie C. Kendalla *et al* explained a method based on the low back pain problem. Functional musculoskeletal conditions are widely thought to cause mechanical low back pain. The role of foot posture and leg length discrepancy in contributing to abnormal biomechanics of the lumbopelvic region and low back pain is not sufficiently investigated. It also explores the evidence for a role for foot orthoses in the treatment of this condition. There is a body of evidence to support the notion that foot posture, particularly hyper pronation, is associated with mechanical low back pain. Mechanisms that have been put forward to account for this finding are based on either mechanical postural changes or alterations in muscular activity in the lumbar and pelvic muscles. More research is needed to explore and quantify the effects of foot orthoses on chronic low back pain, especially their effects on lumbopelvic muscle function and posture.

3. Proposed System

Working Principle

In my proposed system the load cell is placed in the trolley machine which acts as a transducer (LC101-100 load cell). It is used to obtain flexion and extension forces of the fingers and grips. The load cell produces output signals in mV scale. A bridge amplifier/signal conditioner module was used to amplify the signal to a +5 to -5 Volt scale and filters background noise. An EMG electrode is placed on the human forearm to calculate the muscular force. When a muscle is contracted, the SEMG electrode picks up an EMG signal. Then the preamplifier boosts the signal high enough to prevent electrical interference. The preamplifier also filters the noise. The DAQ system is used to collect the different signal from SEMG electrode.

Virtual Instrument (VI) interfaces used for both collecting data and providing the user with an interface for each type of contraction trial conducted during testing. The load cell is used to calculate the force exerted by the fingertips of the employee. The value of the force exerted is displayed by using the LCD. A threshold force value is fixed and it is compared with the actual force exerted by the human being. If the actual force exceeds the threshold value of human beings will be affected in a way like sprain, bone rubbing, deficient limp. So an alarm is provided to indicate this situation to avoid the above mentioned accidents.

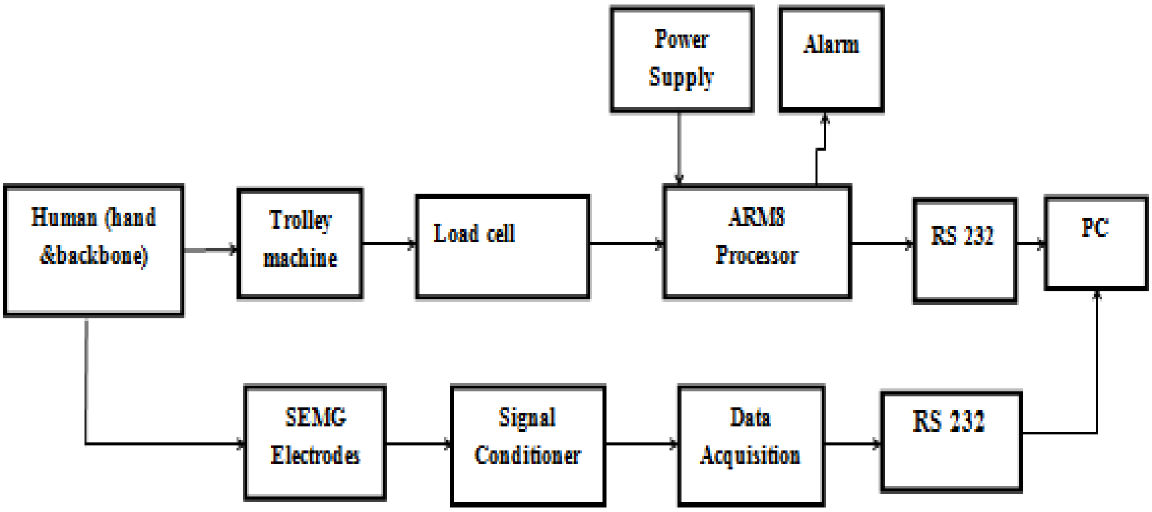

Figure 2. *Block diagram of proposed system.*

4. Hardware Description

4.1. ARM Processor

ARM is a family of instruction set architectures for computer processors based on Reduced Instruction Set Computing(RISC) architecture developed by British company ARM Holdings. A RISC-based computer design approach means ARM processors require significantly fewer transistors than typical CISCx86 processors in most personal computers. This approach reduces costs, heat and power use. A simpler design facilitates are more efficient in multi-core CPUs and higher core counts at lower cost, providing improved energy efficiency for servers.

4.2. Load Cell

A force transducer (LC101-100 load cell) was used to obtain flexion and extension forces of the fingers and grips. The load cell produces output signals on a mV scale (0.3 mV/lbs up to 30 mV maximum). A bridge amplifier/signal conditioner module was used to amplify the signal to a +5 to -5 Volt scale and filter background noise. The force channel was acquired at a sampling rate of 4096 Hz (16-bit resolution) by the DAQ for various lengths of time.The LC101-100 is an S type load cell which provides both tension and compression output readings.

4.3. LCD

A liquid crystal display (LCD) is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). LCs does not emit light directly. They are used in a wide range of applications including: computer monitors, television, instrument panels, aircraft cockpit displays, signage, etc.

4.4. RS232

In telecommunications, RS-232 is a standard for serial binary data interconnection between a DTE (Data terminal equipment) and a DCE (Data Circuit-terminating Equipment). It is commonly used in computer serial ports. The standard does not define such elements as character encoding or the framing of characters in the data stream. The standard does not define protocols for error detection or algorithms for data compression.

4.5. Data Acquisition System

The purpose of data acquisition system is to gather useful measurement data for characterization, monitoring, or control. Data acquisition systems (DAS) interface between the real world of physical parameters, which are analog, and the artificial world of digital computation and control. With current emphasis on digital systems, the interfacing function has become an important one; digital systems are used widely because complex circuits are low cost, accurate, and relatively simple to implement.

5. Software Implementation

5.1. Keil C

Keil Software makes C compilers, macro assemblers, real-time kernels, debuggers, simulators, integrated environments, and evaluation boards for the 8051, ARM, and XC16x/C16x/ST10 microcontroller families. The Keil µVision Debugger simulates the complete ARM instruction-set as well as the on-chip peripherals for each device in the AT91 ARM/Thumb microcontroller family. The integrated simulator provides complete peripheral simulation.

- Added optimized Library and Real-Time Kernel.
- The uVision4 Debugger provides complete simulation for the CPU and on-chip peripherals of most embedded

devices

- Added functions or for special simulation capabilities (E2PROM, I2C communication, and so on).
- Improved the Version Control Connection and corrected several problems with environment variables.
- Added several new items to the Help Menu.

5.2. Flow Chart

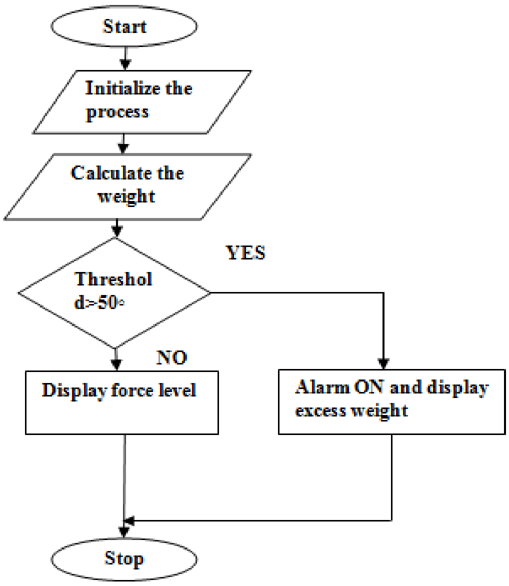

Figure 3. *Flow chart.*

5.3. Algorithm

Step1: Start the process.
Step2: To initialize all the value.
Step3: Calculate the weight.
Step4: If weight is compared with threshold value.
Step5: If the weight is below the threshold different force level will be calculated.
Step6: If the weight is above the threshold value, the alarm will be indicate and excess weight will be display by using LCD.
Step7: Stop the process.

6. Simulation Result

The serial communication or UART window displays the weight and different force level of the object. If the user selects the option 1, the UART window displays the weight of the object. If the user selects the option 2, the UART window displays the pushing force of the object; option 3 means the window displays the pulling force level. If the user selects the option 4, the UART window displays the lifting force of object.

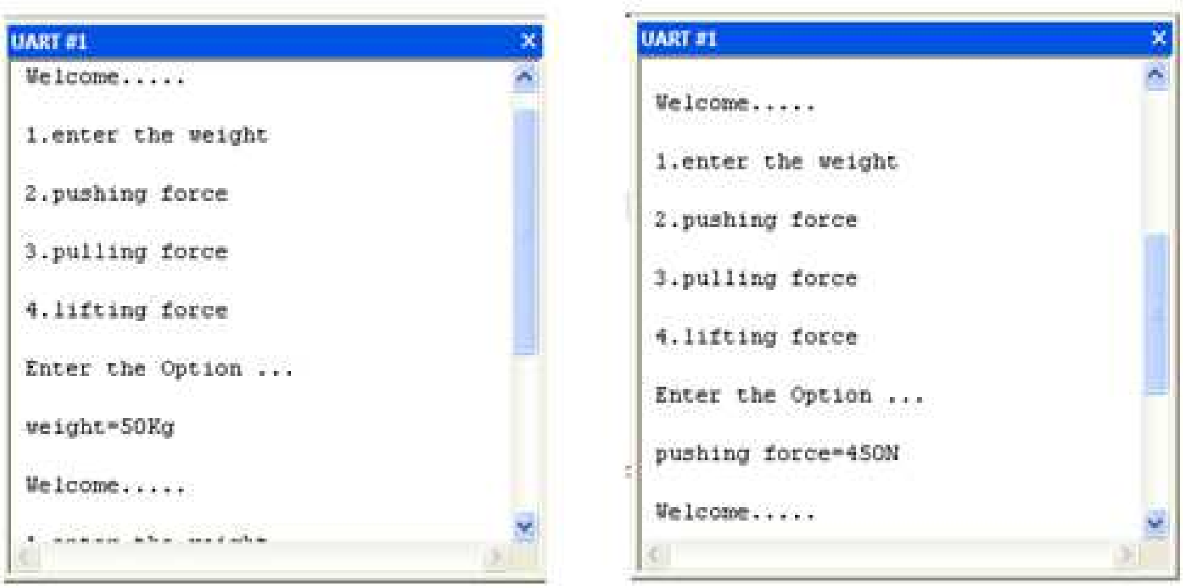

Figure 4. *Output of pushing force.*

7. Conclusion

This proposed system provides safety lifting of human beings while employer handles the objects in the Hot Rolling Mill in the steel plant. So due to the problem causes of accident like sprain and bone rubbing etc., An alarm indicates excess straining of muscles due to said above activities. The additional man power requirement can be decided by using the force value which is displayed in the LCD display or by providing additional man power till the alarm gets off.

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