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Posture determination by using flex sensor and image analysis technique

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ABSTRACT

In the sense of safety, searching solutions for the problems of farmers may face during their work in the field of agriculture is important. For this reason, in this research, developments in sensor technology and price declines are also considering, a safety tracking system with an audible warning support developed for any threshold value that selected during a posture angle measure of agricultural work. To achieve this goal the low cost, 11.25 cm long flex sensor is used with Arduino UNO R3 Development Board. In this way, human motion information for different purposes determined with flex sensors which placed on the various joints as a biometric application. Posture measurement also evaluated with image analysis technique. The system performance revealed the relationship between flex sensor and image analysis measurements, the regression coefficient between the angle change and the voltage output of the flex sensor found as 88.9 %, also it is seen that the regression relation between the angle change and the voltage output of the flex sensor fort he arm angle measurement is 80.7 % and the regression value for the leg angle measurement is 79.9 %.

Key words: Agriculture, Arduino, Flex sensor, Image analysis, Posture identification.

INTRODUCTION

New technologies and fields of applications of these technologies are rapidly developing, and this development has promptly taken place in our lives in parallel to these technologies. Some of these technologies is low-cost development cards and low-cost sensors that can be integrated and used together. These cards and sensors help to develop prototype products that can be used in various application areas. This is also the case for wearable electronic technology. Wearable electronic technology emerges as a new subject in agriculture. Work security and workload in agriculture are vital for human health. Because agricultural jobs are heavily qualified, if they are assessed physically. The change in body angle with biomechanically loadings affects the center of gravity of human and this condition is important for protecting human health.The important thing is to determine the critical values that will not harm the human body. In this regard, there are the "maximum portable load" weight levels, which is accepted by the countries, as a decision of the World Labor Organization (ILO). When these loads and agriculture are considered together, it is important that using wearable electronic technology is used in this sense regarding human health and safety. A variety of studies have been carried out in this area.

Saggio *et al.* (2014) found statistically the relation between the hand holding positions and the measurements of elasticity sensor. They found the pearson correlation coefficient as 0.98 of this relation. As an example of this, Öz and Alayunt (2011) stated that the work in the field of livestock has been mechanized and the physical loads of the workers have been reduced. Despite this fact, they have now defined livestock as an area that contains stresses from the ergonomic point of view, especially with musculoskeletal diseases. They stated that this situation originated from wrong working positions.

Enez and Nalbantoğlu (2015) used the REBA method for regarding wrong activities in forestry and reached to the result that the production work in forestry is "moderate."

Electronic sensors and development boards also use for helping to human in the view of ergonomics. For example, Akkan *et al.* (2012) programmed the micro-controller on the Arduino development card, and using the data obtained from the flex sensor implemented an animatronic hand; they controlled the servo motors.

Karaçizmeli *et al.* (2014) used a flex sensor placed on a glove for a mechatronic-based robotic hand control. The angular values of the fingers are sensed and processed by a microcontroller, and they used this data for control of servo motors and robotic hand controls. In their work, they saw that a robotic hand could imitate the movement of a human hand put on a glove. This proves that the robotic hand can be used in contactless and remote environments that can be harmful to humans in a variety of environments.

Korkmaz *et al.* (2016) designed a robot arm that mimics the movements of the fingers according to received signals. Using a 3D printer, a flexible hand glove model was developed by them, flexible glove placed on an ordinary

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glove, this developed system turns motions into electrical signals and this devepoed system give chance for different servo motor systems work together.

Tripathi and Pandey (2011) worked on impact of drudgery reducing technology on ergonomics of rural women engaged in milking of animals. They refer the correct posture degree affect the heart rate of rural women engaged in milking of animals.

OWAS, REBA, etc. posture assessment studies are based on observation measures. In this study, an electronic measurement system was used for this aim. Also in this study, considering the developments and price decreases in sensor technology, it is aimed to provide a safety monitoring system which gives an audible warning by measuring the posture angle which can be formed on some threshold value, which can be selected during agricultural works. The data of this system are compared with the image processing technique measurements. The relationship between the results is explained by the regression values and the regression equations, and it is discussed in the result section of the research.

MATERIALS AND METHODS

In the study, measurements were made of 10 individuals with an average age of 25 years old, 170 cm height and 75 kg weight for different joint angle measurements. Individuals were chosen with the thought that the system would be preferred by younger employees. Images were taken to determine the angular change between support points during the study. A tripod and a Logitech C930e webcam were used for taking images, 0 degrees to the 135 degree angle between the limbs was performed in 45 degree angle increments. As a result of the angle changes, a fixed point is used to determine the angle of bend (θ) in the limbs. The angular change between the support points was determined via the Iconico Screen Protractor software (Fig-1).

For wearable electronic measurements, the Arduino development card used for data evaluations (Fig-2).

Considering the improvements and the price reductions of the sensor technology, a 11.25 cm length flex sensor, a resistance of about 10 kΩ when not bent and a resistance of 20 kΩ when it is bent used with the Arduino UNO R3 development board (Fig- 3). In this way, it become possible to determine any threshold value that can be selected, and a buzzer can be used as a sound output on the direction of these values (Fig-4).

Also used the HC-05 Bluetooth card used in the research, which has 10 m of communication distance for wireless data transfer in an independent, secure and fast way to a portable computer (Fig-5).

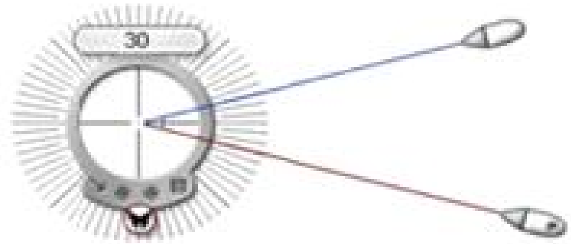

Fig-1: Iconico Screen Protractor software

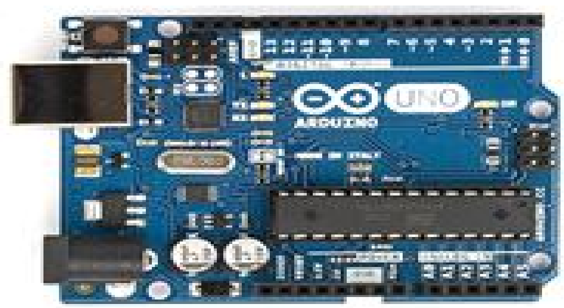

Fig-2: Arduino UNO R3 development card

Fig-3: Flex sensor

Fig-4: Buzzer module

Fig-5: HC-05 Bluetooth module

In the study, a 9 V power supply was used for the Arduino based development card and sensor energy needs, which requires a minimum of 5 V of energy (voltage).

Angle measurements were made over the joints of the arms and legs to determine posture positions. Angle change were made between 4 different positions from 0 degrees to 135 degrees with 45 degree increments. As a result of the angle changes, constant point was used to determine the angle of bend (θ) in the limbs.These constant points selected as shoulder, elbow and hand points for arms and ankle, knee, and waist points for the legs (Figure 6 - 7). Measurements between arm and leg joints were taken as angular values of joints point at different positions (Fig 6 - 7). Data reading were done in such a way that 1 data measurement is taken electronically for each of 80 position readings. For each of a data measurement, reading were taken for 60 seconds, and the average of these data. A total of 4800 data was statistically analyzed by using average of the measured value.

A Logitech C930e webcam was used to capture the images, and it set via the computer interface for 1280 x 720 resolution for shooting. It is possible to develop a variety of algorithms for evaluation of images and use a program or some package software. In this study, the angular change between arm and leg points was determined via the Iconico Screen Protractor software from taken images. The results were evaluated from the measurement of 40 hand and 40 leg positions with 80 images which is taken from 10 individuals (Fig.8-9).

The work is based on the Arduino development card and the sensor technology which is supported by this card. Arduino development cards are open-sourced equipment with different kinds of analog and digital inputs depending on its type. Arduino cards are use the micro controller which is produced by Atmel.

The card has a mobile Atmel microcontroller connected with the card, and other circuitry that fulfills various functions and provides communication. These cards can be programmed effectively and easily with an Arduino programming platform developed in Java environment and libraries belonging to this platform. These cards can process signals by communicating with various analog and digital sensors, and these results can be used as a source for other control units. It is important to determine the optimal microcontroller capacity and the number of inputs/outputs to be able to work with these improvement profits regarding operation to be performed. It also affects the success of this study. The Arduino UNO card was chosen for this study (Figure 10-11). Microcontroller programming has been done using the USB interface of development board with Arduino IDE. During the programming of the Atmega328 microcontroller on the

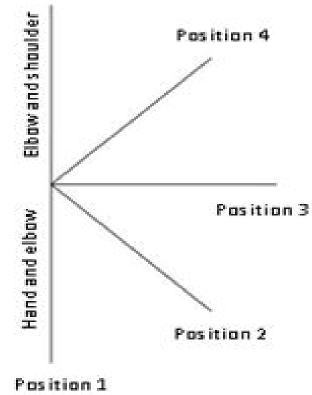

Fig-6: Arm positions

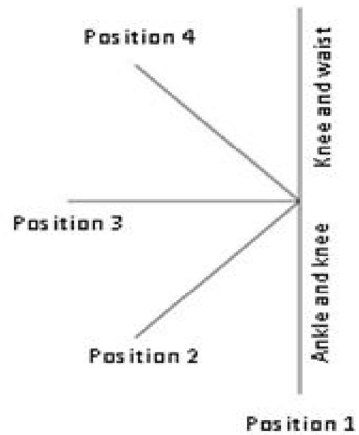

Fig-7: Leg positions

Fig-8: Arm angle measurement with Iconico Screen Protractor software

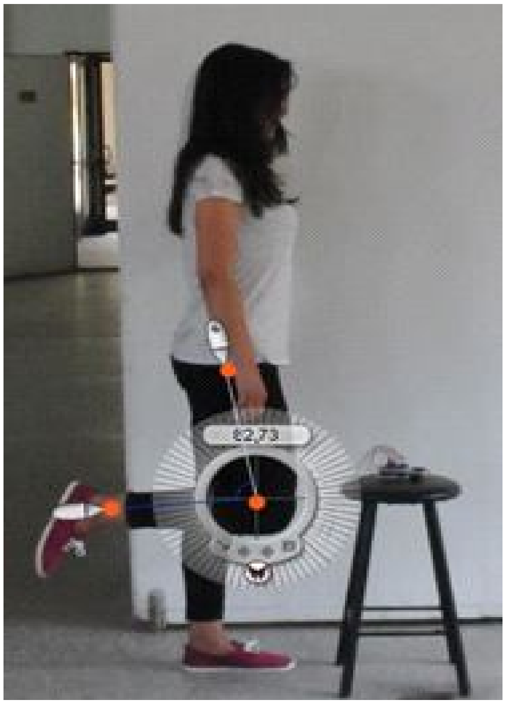

Fig-9: Leg angle measurement with Iconico Screen Protractor software

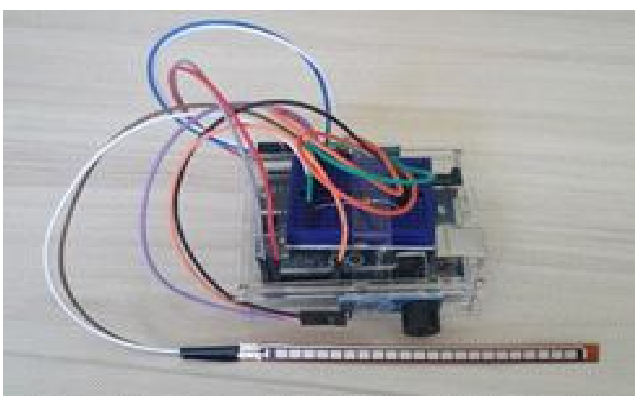

Fig-10: Developed flex sensor measurement system

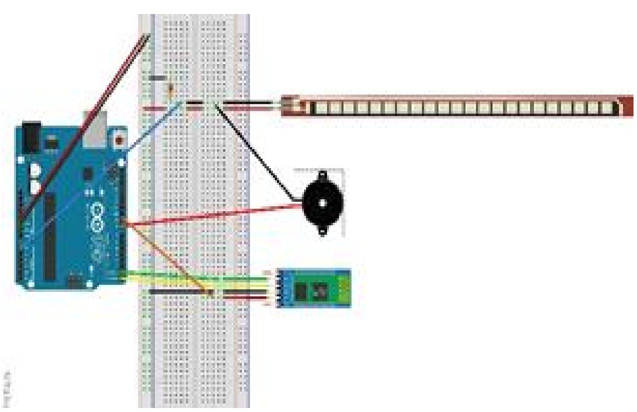

Fig-11: Wiring diagram of the measurement system with flexible sensor

Arduino development board, the data transmission rate is set to 1 data per second. The average of 60 data read in the measurement weretaken and recorded as the main measurement value.

In the study a computer used with an 11-inch monitor, a Pentium i5, a 1.9 GHz processor, 4 GB RAM and an Intel Graphics 6000 video card to read the data. Minitab v16 statistical package program was used to evaluate the obtained data and to find the regression equations, and the regression between the angular change and flex sensor data.

RESULTS AND DISCUSSION

Initially, the flexibility sensor was bent every 10 degrees with an angle meter for calibrating and characterizing, then the voltage and characterizing process of the sensor with the voltage value readings. Figure 8 shows that the regression equation between the angle change and the voltage output of the elasticity sensor is 89.5%, while the regression equation is also shown on this graph (Fig 12).

Subsequently, a biometric application was made that allows the flex sensors to be placed in different joints in the human body to provide information for different purposes according to the movement type. Posture measurements were also supported by image analysis technique. When figures 13 and 14 are examined graphically, regression equations of the regression relationship between the angle change and the voltage output of the flex sensor in arm and leg angle measurement can be seen.

When these relations are examined, it has been determined that maximum of 9% deviation in the level of the relationships between the measurements made on the human motion and the characteristics of the sensor. As a result, this method can be used as wearable technology within these tolerance values, furthermore, it can be used to determine human posture and to control human health by using these values. The measurement system is not suitable for everyday use as a prototype, the final product is the main option for this aim. Therefore, there is no reason that it should not be preferred in the case of casual wear.

When the graphs of the regression equations are examined, it is seen that the regression relation between the angle change and the voltage output of the flex sensor is 79.9% at the arm angel measurement and the regression value of the leg is 80.7%. In Fig-12, is a non-linear graph, but close to a straight line, when it is carefully observed. For this reason, a linear regression model was used. Also, in fig. 12, voltage value increasing while the angle value increases. On the contrary of Fig 12, fig 13 and 14 shows taht the angle value increasing, while the voltage values decrease. Because bending directions of the flex sensor is the reason of this condition when it is observed.

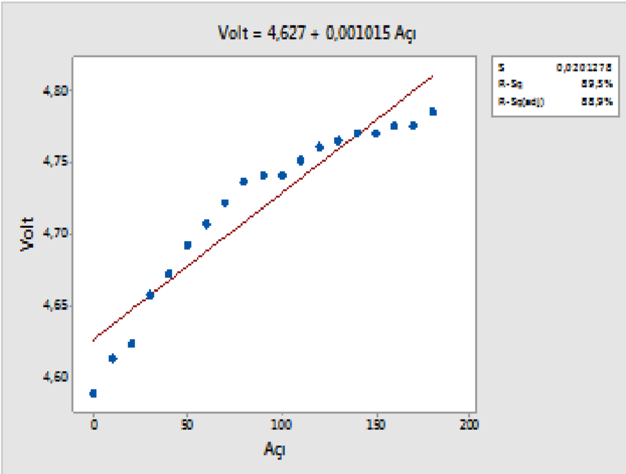

Fig-12: The regression relationship between the voltage change and the angle change in the flex sensor

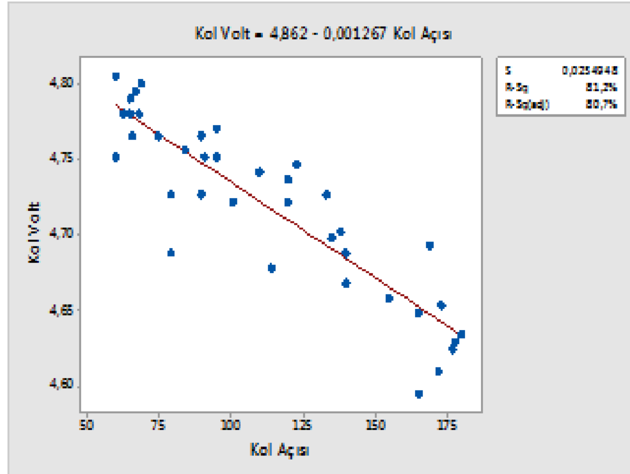

Fig-13: The regression relationship between angle change and voltage output of the flex sensor in arm angle measurement

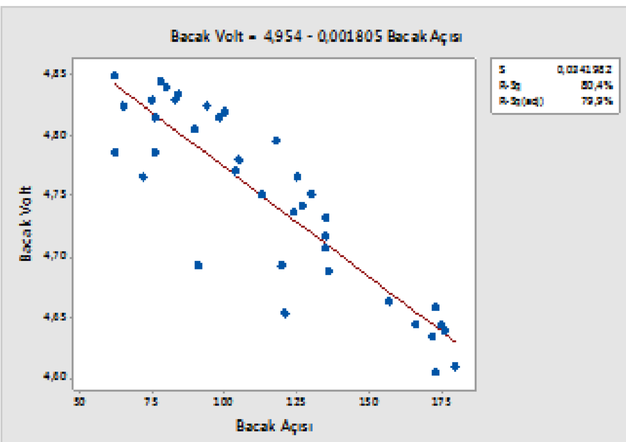

Fig-14: The regression relationship between the voltage change and the angle change on the flex sensor in leg angle measurement

In the literature, Beyaz and Öztürk (2013) investigated the relation between load ratios and average bending angles (è) according to the center of gravity angle (á) while studying the determination of back loading with image processing technique, and found 91.5% and 96.6% regression relation among the centers of weight, respectively.

Beyaz *et al.* (2012) worked on posture analysis by using the OWAS method at milking facilities and also used an image analysis technique in evaluating the postures. In the light of obtaining data; they have concluded that workload of the agricultural work is low, but they point out that the number of workers is another factor of the work load determination. In this study, a similar image analysis technique was used to verify the success of the developed electronic measurement system. Detecting the angles of the arms and legs is not enough to determine the risks associated with posture, but the developed prototype will be in the initial phase, perhaps additional systems can be develope in the future. Factors such as strength, the number of repetitions can be taken into consideration in a new study.

In practice, it is possible that warping the user with an alert sound when the angle in the arms and legs exceeds a specified threshold value,but it can cause other objectionable situations. We can overcome to this situation with training and awareness-raising activities. Despite all security measures, this risk is a concern for every system. Although there are many security precautions that are still used in many works today, also work accidents are still continue to happen. This is why we are working to get better measures for human security. Nowadays, this technology can be used to measure angles in the laboratory environment, but in the near future, these systems will be in our lives. Smart watches can be show an example of this condition, which is wearable and used to control human health.These kinds of systems are still developing and widespreading, they are in their infancy, and even acquiring a serious commercial potential in the markets.

As a result, this method can be used as wearable technology within these tolerance values. Furthermore, it can be used to determine human posture and to control human health by using these values.

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