Development of a posture detector using a flex sensor

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Postures define the relative positional arrangement of different parts of a person's body. A good or ideal posture describes the alignment of the body when all body parts are balanced and symmetrical around the line of gravity, while bad or poor postures occur when asymmetric relationships are adopted (Bryant & Green, 2010). The four most common bad standing postures are Kyphosis-lordosis, Flat-back, Sway-back, and Scoliosis. When a person is maintaining a good posture, the spine is aligned with minimum internal muscular stress and maximum efficiency of external strain (Kendall, McCreary, Provance, Rodgers, & Romani, 2005). When a person is maintaining a bad posture, the stress on the curvature of the spine is increased which causes muscle fatigue. Bad postures are formed by bad standing, sitting, and moving habits and inaccurate implementation of body alignment (Bryant & Green, 2010). Bad posture not only detracts from a person's appearance, but also may lead to chronic injury and pain in muscle, joint, and ligaments, or even disability (Grandjean & Hünting, 1977; Kendall et al., 2005).

Correcting bad postures requires correct kinesthetic awareness. This is not easy for people who have already developed bad postures with bad habits and inaccurate self-awareness. A posture detection device is helpful to remind users when a bad posture happens and can assist them in taking corrective actions. It is also important to design a device that is unobtrusive and cost effective. With advancing wearable technologies, there are some posture control and correction devices on the market, such as the Lumo Lift (http://www.lumobodytech.com/lumo-lift) and the Upright (https://www.uprightpose.com). The Lumo Lift uses accelerometers to detect changes in its mounting angle, is worn near the left or right clavicle, and gives no direct measurement of the lumbar spine curvature. The Upright does give a direct measurement of the spine curvature, but must be affixed to the lumbar spine with adhesives. In this project, we employ a flex sensor that changes with spine curvature, but is not affixed to the skin. Our flex sensor can be worn in a garment and can sense the angle of bending by changes of its resistance value (https://www.sparkfun.com/products/8606).

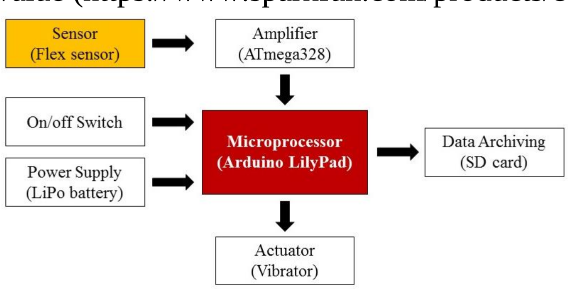

Figure 1 Setup diagram

We have found that changes in the sensors resistance can be related to changes in posture. No other reports of similar uses of flex sensors were found in the open literature. Therefore, we adopted this approach to develop our wearable posture coach. The development process was designed to answer four questions. (1) How to embed a posture detector into clothing? (2) How to scale the sensor's signal so that changes of postures are detectable? (3) Where to place the sensor to maximize the signal change between good and bad postures? (4) How to calibrate the detector so that it adapts to different users with different body structures? Fig. 1 shows the setup diagram of all modules.

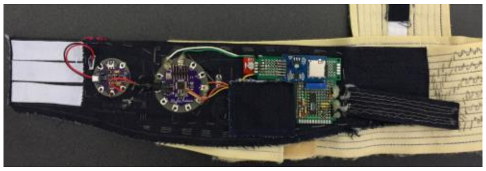

Figure 2 Developed device

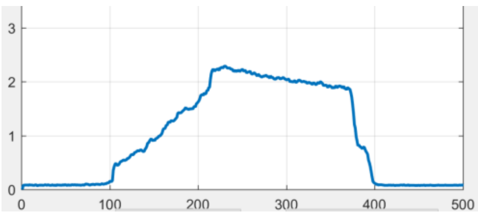

Figure 3 Signal changes at lumbar region (x in samples, y in volts)

Figure 4 Posture test on a subject (left, good; right, bad)

To answer question one, the sensor and signal processor were embedded on an elastic wrap that was comfortable to wear (see Fig. 2). Metal blended conductive threads were sewn into the garment to connect the different modules. To answer question two, amplifiers were used to scale the sensor's voltage by a factor of 21. The gain ratio was determined by trial and error. To answer question three, a flex sensor (held in place by straps over the shoulders) was placed at three locations along the spine. Signal changes for these three locations were compared. It was observed that when the sensor was placed at the lumbar region (upper waist), the changes were most obvious and consistent (see Fig. 3). In Fig. 3, the subject was in good posture at time 0 through time 100 samples (1 sample – 0.1 sec). She started to bend her spine at time 100 and reached the bad posture at time 220. Bad posture was maintained through time 370 and got adjusted at time 400. Therefore, lumbar region was used as the placement location of the sensor. To answer question four, a calibration procedure was built into the device. Users were asked to maintain good postures every time they turned on the device. The device would capture the initial resistance/voltage value during the first four seconds. The initial value, which varied from person to person, was used as the base value for their good posture. A vibrator was added to indicate when the calibration process was finished. It was also employed to alert the user when bad postures were detected. The developed prototype was tested in various bad posture scenarios; it detected the bad posture challenges (such as the slouch in Fig. 4) and alerted the user.

Metal blended conductive threads were used in the prototype. However, the resistance of those conductive threads degraded the system's sensitivity. For future study, better conductive fibers should be considered. An Arduino LilyPad was used as the microcontroller for the prototype. To reduce the size and increase aesthetics, an encapsulated leaner circuit is recommended.

References

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