Investigating sensor attachment methods

And selecting the best methods for use when measuring with ultrasound transducers

D.A. Koetsier,
Industrial Design Bachelor,
University of Twente,
The Netherlands.

Analyzing the problem and investigating better sensor attachment methods.

During the minor Bio Robotics in the first quartile of 2017, this assignments field of expertise was experienced. Since the minor was enjoyable and the tutor back then informed about a new development, there was looked for a connected bachelor assignment. The PhD research of Niu was published on the 15th of February 2018 [1], and contact was established with the group at the University of Twente to see whether this newly developed technique still needed some research and designing. After discussing a few options, which were limited by time and costs, one problem remained that could still use some research. The method used for testing this newly developed technique was painful and not sophisticated, since it was not developed past applying as much tape as necessary on the skin, to fixate the holders. Therefore, improvements can be made regarding the method for attaching the holders to the legs. The bachelor assignment would regard finding new and existing ways to attach sensors and selecting the best methods for attaching the holders.

Main question:
Which possibilities are there for applying sensors on the skin of a human leg and can they be combined with the ultrasound method to improve the application regarding comfort, wearability, durability and signal perception?

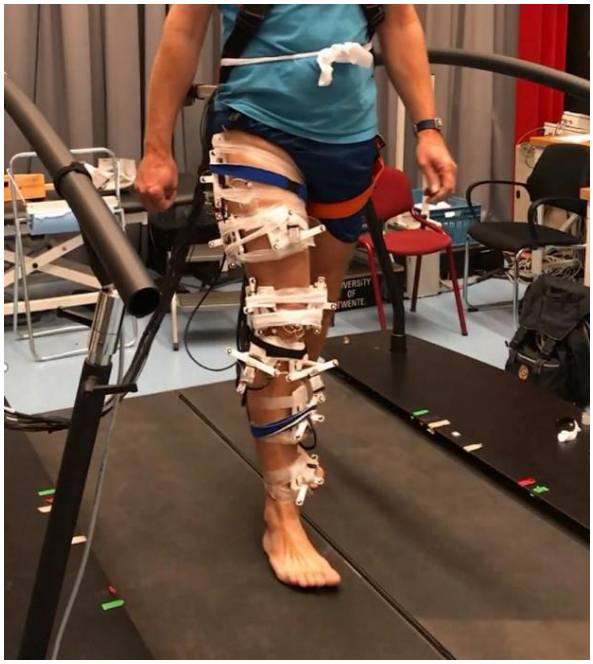

Figure 1: Currently used method for the ultrasound set-up

A new technique, which uses ultrasound to capture skeletal motion, has been developed [1]. The idea is to track the position of the bone using data from both ultrasound transducers and optical trackers. Determining the location and orientation of the bone in this way makes it possible to create a 3D model using kinematic calculations. However, the experiments are painful for the user and the signal perception has not yet reached the required accuracy. The problem is the attachment method, which currently uses elastic straps and skin tape, the last of which is especially painful when removed (figure 1). When this technique is going to be further developed it is important that experiments can be conducted quicker and are a more comfortable experience for the test person. To find the answer to the main question, the internet was searched for attachment methods. These methods were taken as a guideline for a

search plan composed to find papers with more information about the attachment of sensors. Furthermore, interviews were conducted with people from the University of Twente as well as companies to gather practical information about attachment methods. The results from these investigations where compared and used to select methods that were interesting to investigate further. These methods included double-sided tape, a brace, straps and GrifGrips. Several methods where not investigated further. Gel and glue where too expensive and netting, clips and gecko tapes were considered less appropriate than the selected methods [2]. The selected methods were tested on signal perception, comfort and wearability. During the tests, three main complications were found that exclude some of the methods:

Figure 2: The ladder lock plastic side buckle (own picture)

- Every holder is assigned a unique spot to be able to measure a specific point cloud of the bone structure position [3].

- LED-indicators are rigidly attached to the holders and stick out perpendicular to the holder surface [3].

- On several location there are multiple holders that need to be attached on the same circumference [3].

Figure 4: Plastic side release buckle (own picture)

Evaluating and testing with these complications in mind, resulted in straps being the best solution, because of their comfort and compatibility with the holders. Three concept methods (figure 1, 2 and 3), which include straps, where chosen to be tested in an experiment. The goal of this experiment was to obtain values to compare the methods and to investigate whether the concept methods are improvements over the current set-up. As a result, the concept methods were shown to be better than the current method. In conclusion, the best method was the plastic side release buckle, because it enables the user to quickly release and attach the strap with the holder attached. This is helpful when extra gel needs to be applied between the transducer and the skin to keep the contact airtight. However, the winbag was the most comfortable according to the user. Combining these two methods would be something that requires further investigation.

Figure 3: Winbag

References:

1. Niu, K. (2018). Ultrasound Based Skeletal Motion Capture the Development and Validation of a NonInvasive Knee Joint Motion Tracking Method. Enschede DOI: 10.3990/1.9789036544825
2. B, Coenen. (2018). Towards an injury-preventive feedback system for trained long-distance runners. Enschede
3. Johannink, T.A. (2017). Redesign of A-mode Ultrasound holders for lower body kinematics. Enschede.

Figures:

1. Niu, K. (2017). Currently used method for the ultrasound set-up. Received from Sluiter, V.
2. Own picture
3. Own picture
4. Reddiseals. (2018). Winbag. Retrieved from: https://www.reddiseals.com/product/winbag/