Gait Analysis Using Ankle-Mounted Inertial Navigation System

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What is Gait Analysis?

Gait analysis is the study of walking, concerned with the mechanics, dynamics, kinematics and timing of how people walk.

Impaired gait has been shown to be clinically relevant for a number of different applications. For stroke and other types of neurological injuries, walking is a critical measure of recovery and capability, primarily because it is a vital part of daily living. Variability in gait timing and mechanics has also been shown to be a predictor of some types of mental illness. Finally, gait analysis might provide a way to assess falls risk, one of the biggest causes of injuries for senior citizens.

What is this project about?

This project aims to create a general purpose gait analysis tool that allows investigators collect gait data in a convenient and economical way. This capability will hopefully enable the discovery of new knowledge about human locomotion, as well as verifying hypotheses describing links between gait and a variety of medically relevant conditions, ranging from rehabilitation to mental illness and falls risk.

The system currently features two ankle-mounted sensor units, as well as software to process the collected data offline, on a PC. The sensor units contain a tri-axial accelerometer, magnetometer and gyroscope as well as an IR proximity sensor, for a total of 10 sense channels. They are designed to collect up to 1 weeks' worth of data between charges, and to be usable in a clinical environment by a wide variety of healthcare workers.

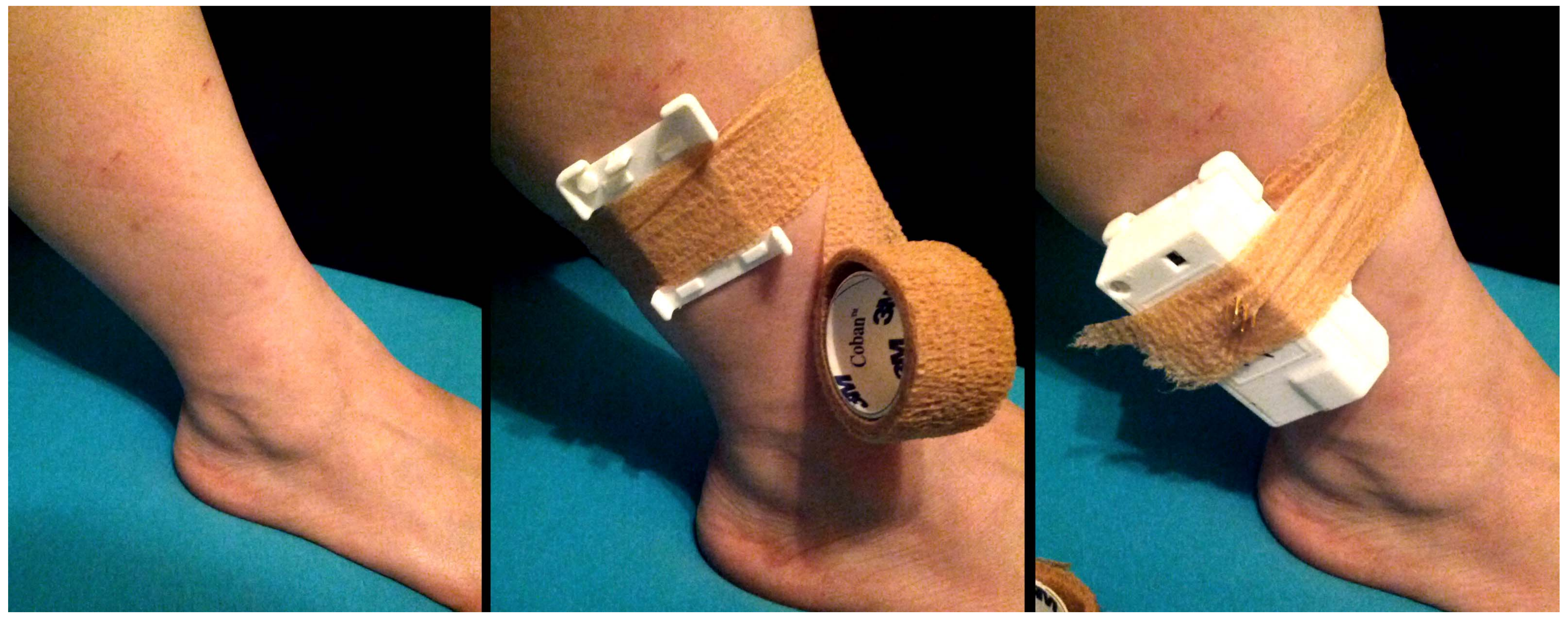


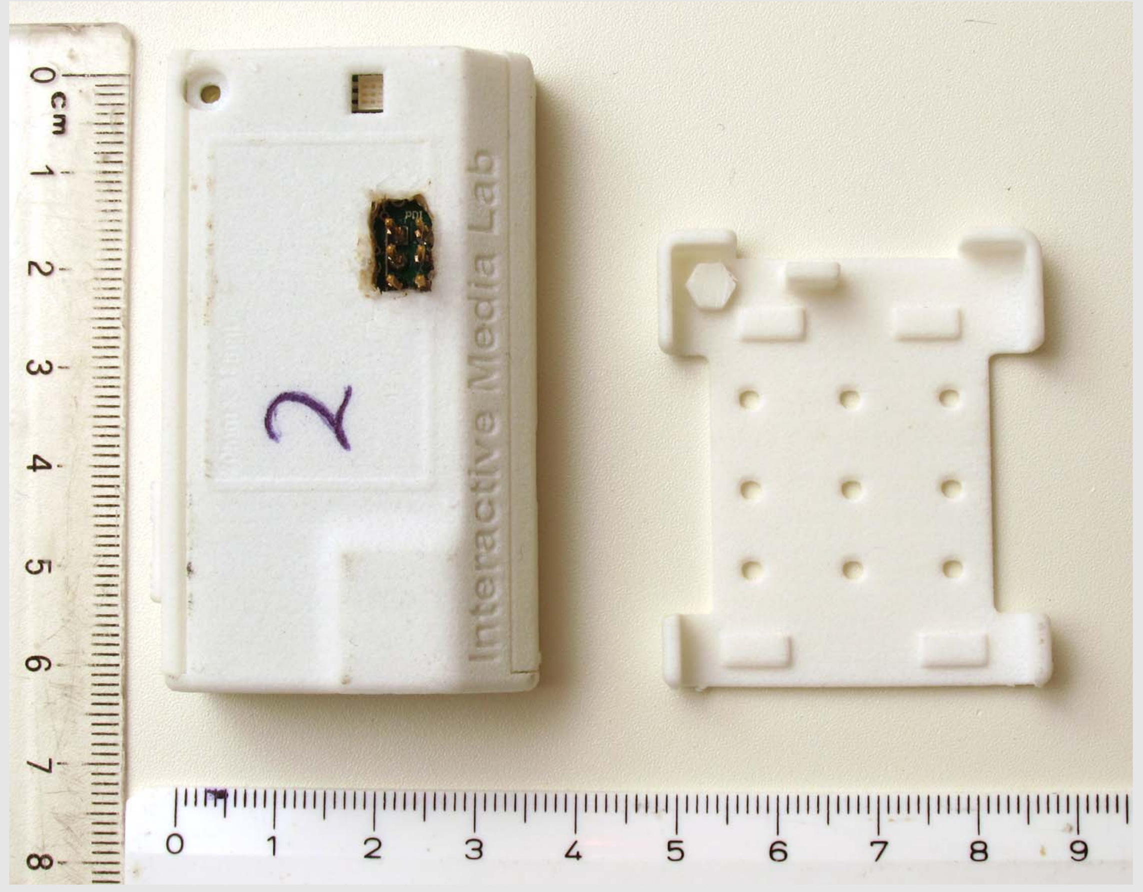
Figure (left): The attachment process is shown in sequence, from left to right.
In the first image **(far left)**, the subject's ankle is shown.
In the second image **(center)**, the retaining clip is taped onto the subject's ankle. This restricts the available degrees of freedom.
In the third image **(far right)**, the device is attached, mating with the retaining clip. To avoid spurious data, the device only records when mated with the retaining clip.

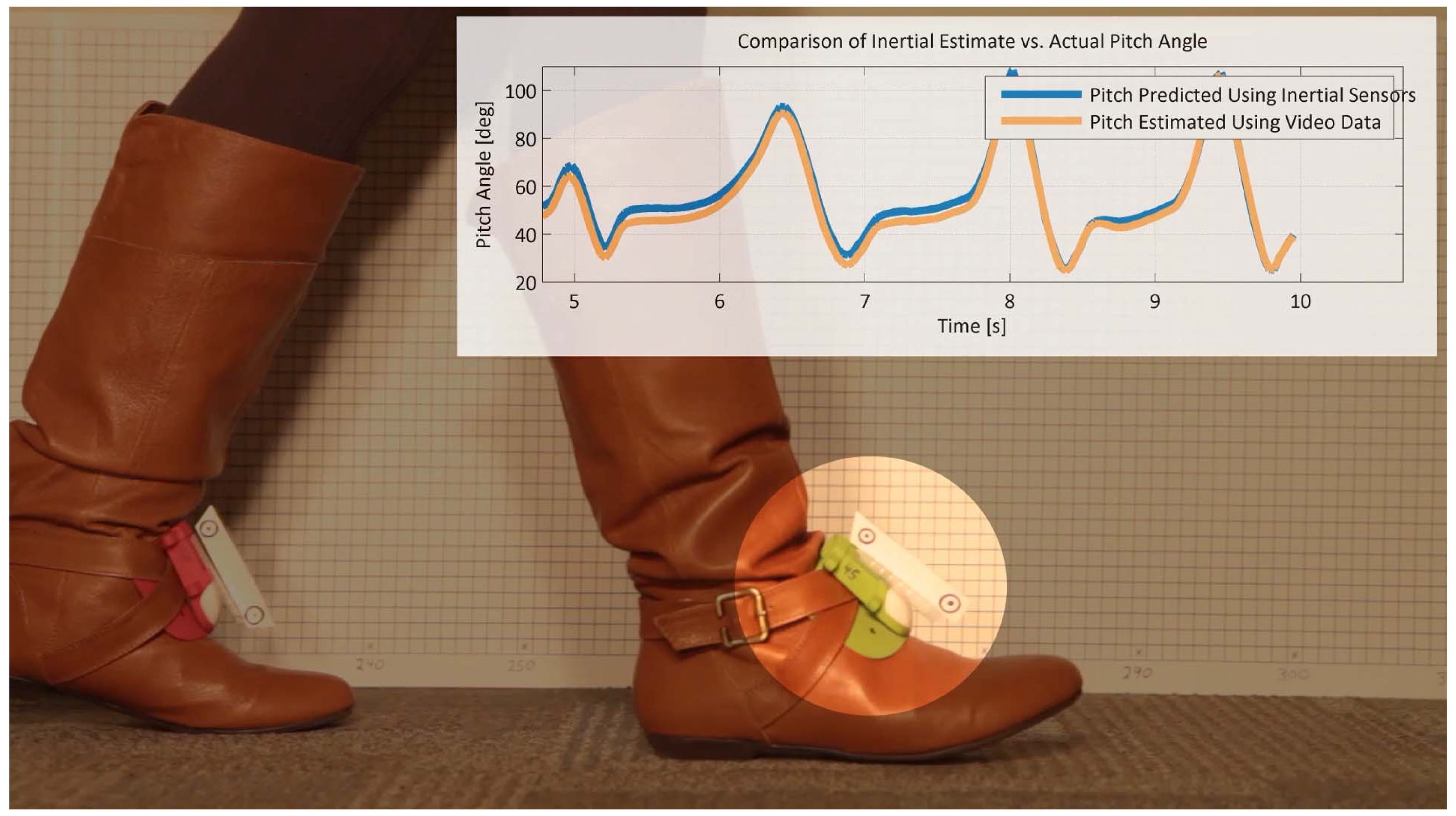
Sensor Hardware

Figure **(right)**: A top view of the prototype sensor hardware. Also shown is the mating clip. The sensor has:

- A 24-hour recording capability, and 30-day standby period.
- A tri-axial accelerometer, magnetometer, gyroscope, and IR proximity sensor onboard.

Figure **(far right)**: A perspective view of the sensor hardware.





Motion Algorithms

The device can measure orientation in space fully, with reference to the Earth's magnetic and gravitational fields. A non-linear complementary filtering algorithm is used to accomplish this.
In future work, it is expected that this information, combined with a model of human motion, will allow for limited trajectory and stance estimation.

Figure (left): The graph shows the pitch angle of a subject's foot as she walks. The pitch angle predicted by the device is shown in blue; data from a camera tracking setup is shown in orange.

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