4.1.3 Bluetooth Acceleration Sensors

Description A set of 12 acceleration sensors were placed on the following body parts:

- Left upper arm up
- Left upper arm down
- Left wrist
- Left hand
- Right upper arm up
- Right upper arm down
- Right wrist
- Right hand
- Right knee up
- Right knee down
- Right hip
- Back

The goal in having pairs of sensors in similar positions is to be able to simulate a range of intermediate sensor placements. The algorithms that will be developed within this project will have to show robustness with respect to what would happen in a realistic situation, where it cannot be guaranteed that users wear a certain sensor in a very well defined position. Each sensor board hosts a triaxial accelerometer and has a Bluetooth interface that allows the signals to be recorded wireless through the CRN Toolbox. The sensors were already used in previous research (see for example [1]).

Figure 8: Acceleration sensors mounted on .

Recording conditions

- Location: 12 body parts
- Sampling frequency: 64Hz, 32Hz (see following text)
- Connection: Bluetooth
- Client side: CRN Toolbox

For the last five sessions, some measures were taken to try to reduce packet traffic on the Bluetooth channels and to improve the data acquisition. To the first end, sampling frequency was thus decreased from 64Hz to 32Hz and only uncalibrated data were sent. Furthermore, the packet counter size was increased from 8 to 16 bits. This allows to detect interruptions up to 65535 samples (34 minutes at 32Hz) without ambiguities, whereas the 8 bit counter allowed only to detect 255 samples (8 seconds).

4.1.4 Sunspots

Description Sun SPOTs (Sun Small Programmable Object Technology) [?] are wireless sensor network motes developed by Sun Microsystems. A Sun SPOT consists of (i) a processor board (180 MHz, 32 Bit, 512K RAM, 4M Flash) with an on-board 2.4 GHz IEEE 802.15.4 radio and USB

inteface, (ii) a sensor board with different sensors (2G/6G three-axis accelerometer, temperature sensor snd light sensor), interfaces (six analog inputs, five general I/O pins, four high-current output pins) and eight tri-color LEDs on top of the sensor board, as well as (iii) a 3.7V rechargeable 750mAh lithium-ion battery. Sun SPOTs are powered by a small-footprint Java virtual machine called Squawk, which can host multiple applications concurrently and does no require an underlying operating system. The Sun SPOT SDK is currently available in version 5.0, and it also includes code samples and an emulator. The entire Sun SPOT project, hardware, operating environment, Java virtual machine, device drivers and applications, are available as open source.
We used the three-axial LIS3L02AQ accelerometer [**?**] mounted on the sensor board of the Sun SPOT. The z-axis is perpendicular to the Sun SPOT boards, the x-axis of the accelerometer is parallel to the row of LEDs on the sensor board and the y-axis is parallel to the long edge of the sensor board. The acceleration for each of the three axes (a_x, a_y and a_z), the total acceleration $|\bar{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2}$ as well as the inclination (tilt) $\Theta_{axis} = arcsin(a_{axis}/|\bar{a}|)$ in radians of each axis with respect to the total acceleration the SPOT is experiencing have been recorded.

Figure 9: Sun SPOT acceleration sensor mounted on a shoe.

Recording conditions

- On-body Location: feet (below the right/left ankle on the right/left shoe)
- Sampling frequency: $\approx$ 10-35 Hz (see text below)
- Connection: IEEE 802.15.4 radio (2.4 GHz)
- Client side: Proprietary Java client based on the Sun SPOT SDK v4.0

One Sun SPOT sensor has been taped to each shoe right below the outer ankle of the foot (see Figure 9). The SPOTs were powered by the integrated 3.7V battery, and the signal of each SPOT was transmitted wirelessly to a dedicated USB receiver which was plugged to a laptop computer. Therefore, the application consisted of two parts, one running on the SPOT and another one running on the laptop computer. For the former, just the reset button of the SPOT had to be pressed in order to start it. As with the Inertiacube3 sensors described in Section 4.1.5, the laptop was carried along to guarantee a constant signal quality whenever the person went outside of the room. We changed the SPOT after each session to recharge its battery, which however sometimes run empty before the end of the session. For several reasons, mainly because of wireless communication problems and manual adjustments to cope with battery life time issues, the sample frequency was not constant but varied between 20 and 30 Hz throughout different sessions.

4.1.5 Inertiacube3

Description Taking feet orientation and acceleration of the human walk cycle as a reference for determining a users gait two Intersense Wireless Inertia Cube 3 sensors were mounted at the toe box the of shoes (see Figure 10). These sensor units include gyroscope, magnetometers and accelerometer with respect to gravity for 3DoF acceleration, angular velocity and orientation updates at a maximum 180Hz rate.

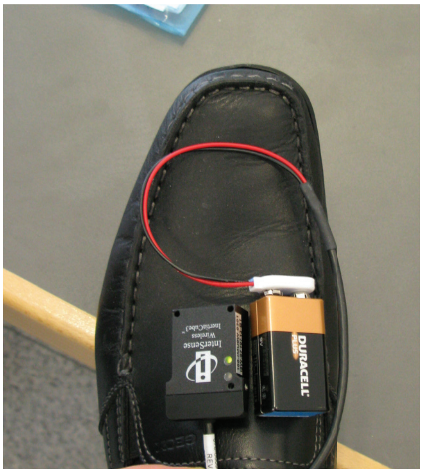

Figure 10: Inertiacube3

Recording conditions

- On-body Location: on left and right shoe toe-box
- Sampling frequency: 40 Hz
- Connection: propietary Inertia Cube radio protocol(2,4 Ghz band)
- Client side: Proprietary Java client using Interia Cube SDK dynamic library (dll) with JNI wrapper in Windows XP.

Remarks: The sensors are powered by 9V block batteries and were taped together to the shoe upper toe box. The signal was transmitted to the laptop using a USB-powered receiver. Whenever the person went outside of the room to go for a walk, the laptop was carried along to guarantee a constant signal quality. At some early recordings the sensor got disconnected due to the power connector that was not compatible with Duracell battery pins and caused. A new (non-rechargeable) battery lasts for one complete session about 4-5 hours.

4.2 Object Sensors

4.2.1 Bluetooth Acceleration+Gyroscope Sensors

Description A set of 12 objects (cup, glass, 2 knives, plate, bread, salami, milk, water, sugar, spoon, cheese) have been instrumented with a sensor each (see Figure 4.3.1). Each sensor board hosts a triaxial accelerometer and a biaxial gyroscope. The sensors have a Bluetooth interface that allows the signals to be recorded wireless through the CRN Toolbox and have a Li-ion battery that allows for 6-8 hours of recording. The sensors were already used in previous research (see for example [1]).