Project:Possibility

Status Document for 2/27 - SunSPOTs Team
SunSPOT Framework and Language for Action REcognition

Concept Development

Our project concept is to use the wireless capabilities and accelerometers of the SunSPOT platform to record and recognize human gestures for command and control applications. Users with limited mobility often have difficulty using traditional computer input devices such as keyboards and mice. Our gesture recognition framework, which we call the SunSPOT Framework and Language for Action Recognition, or SunFLARE, will allow users to dynamically capture movements that they are capable of making (tailoring to a number of physical disabilities) and associate these movements with actions.

We envision SunFLARE as an extensible plug-in framework that will allow developers to add control functionality particular to applications. Examples of the extensible applications that could take advantage of our framework (some of which we plan to develop as part of the semester project) include: manipulation of an on-screen keyboard, development of limited mobility games, and even motor control/physical therapy applications.

Not only will this project benefit the disabled community, but also it can benefit general users interested in associating a particular movement with action. Though out of the scope of our semester project, our gesture recording and plug-in framework could be used to rapidly develop motion response applications for SunSPOTS.

Problem Definition

Disabled users with motor skill deficiencies such as those caused by cerebral palsy, autism, down syndrome, Lou Gehrig's Disease, and multiple sclerosis to name a few, have difficulty using traditional forms of user input when accessing computers. For users with severe disabilities, eye tracking hardware and induction loops are the only alternatives. For people with mild to moderate disabilities, however, we feel that SunSPOTs could offer an attractive user input alternative.

Unlike a traditional mouse that must be used on a horizontal surface and translates physical movements to direct manipulations of the cursor, a SunSPOT-based alternative could monitor any gesture the user is capable of making using its built-in accelerometers.

A framework for gesture recognition could be tailored to an individual’s disability, allowing multiple programs to be customized to respond to an individual’s movement. In

this way, the SunSPOT can act as a powerful input device without the limitations of eye-tracking and induction loops.

Functional Description

SunFLARE is a software framework consisting on a client running on a SunSPOT and a server running on a computer with a base-station.

The underlying software framework will have a plug-in interface that allows developers to create custom callbacks to their own applications. The user (or an assistant capable of handling setup operations) will be able to record movements and associate them with callbacks via a GUI.

As part of the semester project, we will develop a number of example applications using SunFLARE, including a gesture-based on-screen keyboard.

Design Drivers

The major design drivers that we have identified are as follows:

1. The hardware setup (wireless sensor platform communicating with a base-station connected to a computer) dictates as client/server architecture. The software on the SunSPOT will report movement to the server, where the gesture recognition functionality will be deployed.

2. The use of SunFLARE as a general framework for gesture recognition. This design driver suggests that call-backs to applications (application-specific hooks) should be developed using a plug-in framework on the server-side. This plug-in framework is most easily achieved in Java using a factory pattern.

3. Recognition of gestures will be highly dependant on the motor skills of the user. This design driver is TBD currently and is noted as a risk area. As part of the design phase, we propose a prototyping effort that should give us enough information to do a trade analysis amongst the various mitigation strategies we have proposed.

Risk Areas

Most of the risk in the project originates in the motion capture functionality. There are a number of issues that we must address in the course of our design and development, including:

1. Accommodating noise in the accelerometer signal.

2. Tailoring the sensitivity to movement to accommodate variable disability.

3. The balance between numbers of gestures perceived & complexity of gestures.

Noise should not be too much of a challenge as there are two sensors in the SunSPOT (2G and 6G). We should be able to use the less sensitive to capture large stokes and the more sensitive to monitor orientation.

The balance between the number of gestures perceived and the complexity of individual gestures will play out in the development of end-user applications. We don't anticipate needing more than a few different gestures for most of the possible applications we have thought of to this point. Our worst case would be to register a single gesture in the form of movement of any sort – arguably resulting in a system no less responsive than an inductance loop.

Tailoring sensitivity is a more challenging problem. For some users, sensitivity to orientation should be avoided, while for other users, orientation could possibly differentiate gestures. Additionally, poor motor control could impact gesture recognition.

We have developed a number of mitigation strategies that we plan to explore during the design phase of our project. These strategies include the use of pre-programmed gestures, restrictions on the language of gesture recognized (e.g., gestures can only be composed of movement in straight lines), and the use of predefined sensitivity profiles based on the user's motor skill level.

We have scheduled a prototyping effort as part of our design phase in order to explore these risks further and settle upon a mitigation strategy.

High Level Implementation

Figure 1 shows a high-level boxes and lines architecture for SunFLARE. The general notion is that SunFLARE should run as a service on the host computer and communicate with a sensor monitor server that gets information from the SunSPOT. The SunFLARE service interacts with a user interface that is able to monitor and record the motions of the SunSPOT via the Sensor Monitor Server. The SunFLARE service will additionally manage a gesture database and the plug-in framework.

The implementation language for SunFLARE will be Java. The sensor monitor client will run in the Squawk JVM on the SunSPOT while the rest of the SunFLARE system will run on the host computer in a Java 1.5 compatible JVM.

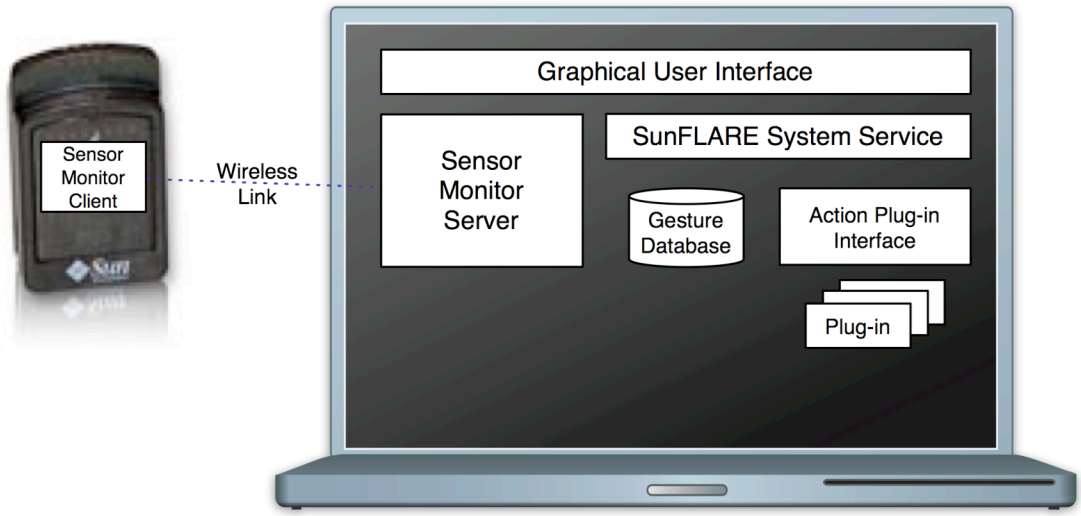

Figure 1. High-level architecture of the SunFLARE project.