AMA, an application for **M**onitoring, **A**nalysis and **M**onitoring
A tool to better understand autism

MAS 771: Autism Theory & Technology
Akane Sano (akanes@mit.edu)
Javier Hernandez (javierhr@mit.edu)

Introduction

People diagnosed with Autism Spectrum Disorder (ASD) are characterized by having restricted interests, impaired communication skills, repetitive behaviors and deficits in social relationships. However, the set of specific symptoms and their severity varies widely from individual to individual. This heterogeneity, along with their difficulty to communicate exacerbates every attempt to accurately diagnose and further understand this syndrome.

One of the most disruptive features of autism is the display of problem behavior. That is, any repetitive behavioral trait that endangers "normal" social interaction with other people due to its inappropriateness. Some of the most common examples include self-injury, rocking, tantrums and hand flapping. Although some research has suggested that these behaviors are aimed at reducing stress levels, to increase attention or to avoid certain events, among others (Turner, 1999), there is little research on how problem behavior is related to the daily environment of each individual. Defining the link between stress level, contextual information and individual traits is of paramount importance to design appropriate behavioral interventions in particular, and to improve their quality of life in general.

To address this problem, we propose the use of the advantages of new mobile phone-based technologies. The system we envision can be separated into three different components:

1) **Annotation**. Continuously tracking the occurrences of problem behavior, is a promising method for evaluating the effectiveness of behavioral and pharmacological interventions. Any annotation tool should be flexible, scalable and easy to use by different people at the same time.

2) M**onitoring**. In order to fully understand individual traits such as sensory processing issues (Tomcheck & Dunn, 2007), multimodal data characterizing the context (e.g., audio, video) need to be collected and synchronized with the previous annotations. Furthermore, physiological data (e.g., skin conductivity or skin temperature) or behavioral data (e.g., accelerometers, location) can help capture the setting event, context and trigger stimulus that lead to problem behavior (Carr & Smith, 1995).

3) **Analysis**. By analyzing the previous information before and after each annotation, the technology should provide relevant correlations between individual traits, contextual information and problem behavior. In addition, this information may be used to predict the occurrence of problem behaviors (Goodwin, Intille, Albinali & Velicer, 2010), and recognize the current stress level of each individual.

Figure 1 shows an illustration of the proposed system. The person with ASD as well as the people around him (e.g., family members, therapists, and teachers) can provide annotations and contextual information of problem behavior through the use of mobile phones. Meanwhile, biosensors can provide continuous physiological data to enrich these annotations. Finally, all data can be analyzed with the state-of-the-art machine learning techniques to provide biofeedback such as the stress level of the person with ASD.

This project focuses on the annotation and monitoring components. First, we review the current annotation tools. Second, we propose a mobile phone application for Android. Finally, we outline some recommendations and consecutive steps for future work.

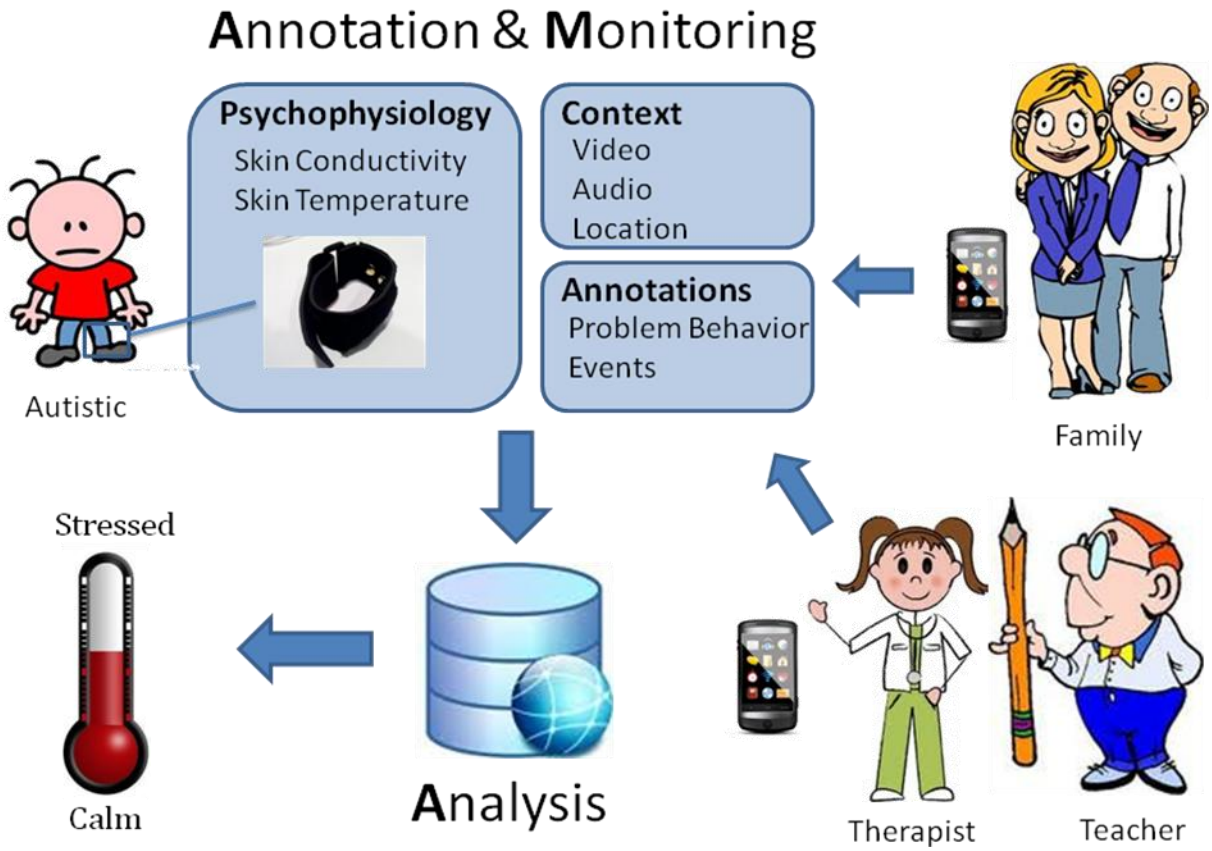

Figure 1. Technology for annotation, monitoring and analysis of problem behavior.

Previous Work

The most common annotation methods in behavioral and psychological studies are based on the use of pen and paper, in which a person writes by hand the occurrence of each event. Although this methodology provides the most flexibility, it is very slow and prone to human error. Occurrence of problem behavior usually increases the cognitive load, thereby delaying the annotation of events. This creates inaccuracies due to forgetfulness and lack of a time of annotators. The economic cost of this type of annotations is relatively small, but it requires someone to manually transcribe the annotations and/or synchronize them with other data sources.

More complex data collection instruments have been explored in the context of autism. Research by Hayes, Gardere, Abowd and Truong (2008), for example, proposed *CareLog* as a system to efficiently annotate problem behavior to support Functional Behavior Assessments. The system requires the installation of cameras and microphones in classes that can be synchronized with the annotations that teachers provide through a four-button remote actuator. Each of the buttons correspond to different manners to indicate onset and offset of annotations. In a separate study, Kientz, Arriaga and Abowd (2009) presents another annotation technology, *Baby Steps*, which allowed long-term monitoring of children to preserve memories and improve communication between parents and pediatricians. This system uses a customized audio/video recording device and software to annotate all of the events. Although both systems have been successfully tested in some real-life environments, their technology

cannot be easily extended to new settings where other contextual or physiological information is required. Moreover, the economic costs of installation is larger than traditional pen- and paper-based methods.

With the introduction of third generation mobile phones, installation costs can be dramatically reduced while preserving the richness of the data. One example is the mobile phone application *EverNote* that allows users to create multimodal (text, video and audio) annotations that can be shared over the Internet. Unfortunately, most of the available applications are aimed at creating memos or to-do lists, which may not accurately represent the domain of behavioral annotations (e.g., tracking the frequency of recurring events.)

Annotation tools for behavioral analysis must allow customizable multi-modal annotations while maximizing usability and minimizing installation costs. In this project, we explore a new mobile phone application that comply these constraints.

Annotation & Monitoring

This section presents an Android application that allows users to make multi-modal annotations and monitor physiological signals in the context of problem behavior.

Application. After visiting a non-profit educational school for people with ASD in Rhode Island, we identified two types of relevant events: classes and problem behaviors (see Figure 2 for details). Teachers at this school use a daily form per student that contains information such as the onset/offset of each class, and the time and duration of any clinically relevant activity of each student. Some of the annotations are spontaneous (only onset is annotated) and others have longer durations (onset and offset are specified), and both types of events can occur simultaneously.

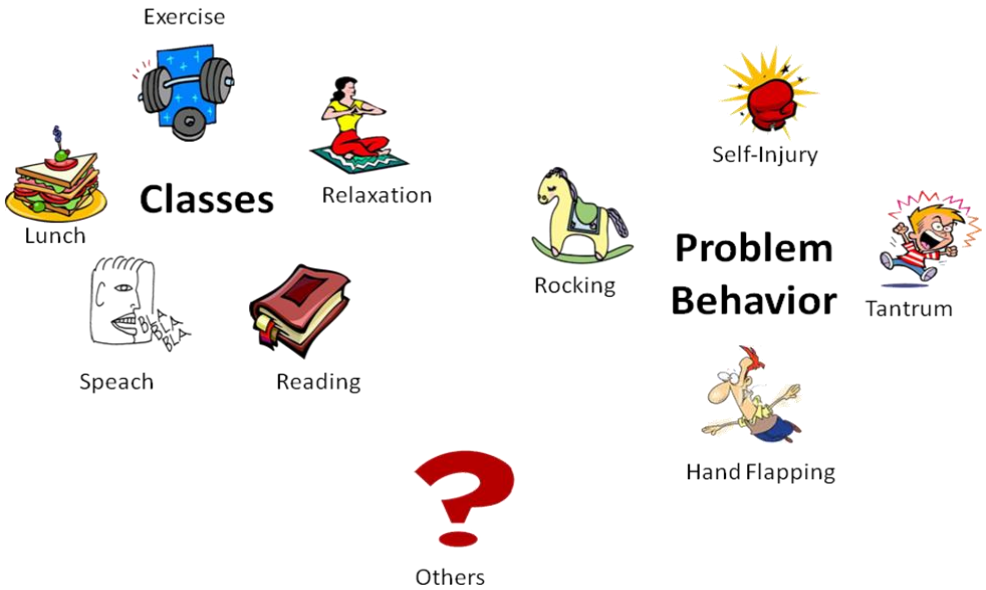

Figure 2. Annotation types and examples of events

Taking the above scenario into account, we have chosen the main screen to be the annotation tool (see Figure 3.) As can be seen at the top left of the device, users can identify student whose annotations belong to. Each of the other buttons can be used to annotate classes (left column) or the occurrence of problem behavior (right panel). By clicking on each button, the user can set the onset of the annotation, and the button color will change to green (Figure 3 right). If the user clicks on the same button twice, the system uses the current time as an offset, and the button color becomes gray. If the button is long pressed after the first click, the annotation will be canceled. Besides changing the color of each button, there is sound and vibration feedback to improve the perception and awareness of the activities being monitored. Multiple events can be simultaneously recorded, and the bottom button (i.e. question mark) allows the creation of undefined events.

Figure 3. Main screen of the application

In order to enrich annotations, the application contains three easily accessible buttons to capture images, audio and physiological signals (top of the screen). The latter one synchronizes the application via Bluetooth with a biosensor developed by the Affective Computing group of the MIT Media Lab (Figure 4 top). This sensor can be comfortably worn on the wrist or the ankle and monitors skin conductivity, skin temperature and accelerometers activity. Real-time physiological information can be presented to the user as shown in Figure 4.

One of the most important factors in this application is the customization of events that is accessible through the settings menu (Figure 5 left). Specifically, the application allows users to create, modify, and delete the types of events and their icons, and to manage students who may be monitored (Figure 5 center). Moreover, all of the annotations can be visualized and managed through a summary list (Figure 5 right.)

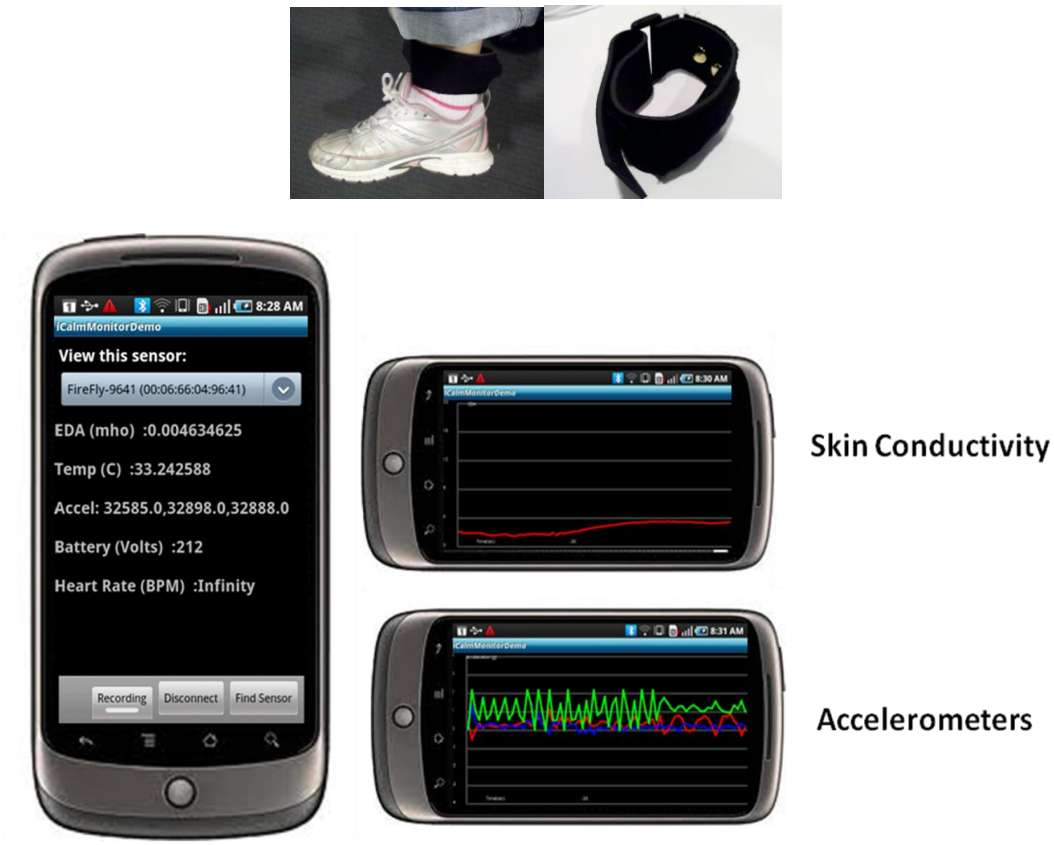

Figure 4. (Top) Biosensor and (bottom) visualization of sensor signals

Figure 5. (Left) settings menu, (middle) student manager and (right) summary of annotations

Benefits. The proposed technology has the following advantages:

- Portable. The device can be used 24 hours/7days a week to annotate and monitor data in real-life environments.
- Scalable. This application can be installed on all Android devices (e.g., mobile-phones, tablets.)
- Cheap. The application uses the capabilities of current mobile-phone devices, and distribution of the software is free through Google's Android Market.
- Customizable. The user interface and annotations can be easily customized. This feature is very important when addressing heterogeneous communities such as people in the spectrum (Morris, Kirschbaum & Picard, 2010.)
- Reliable. With this application, teachers can quickly annotate with one or two button clicks, and will not have to manually transcribe the annotations.

Sharing Information. One of the main potential benefits of this application is the possibility to share and synchronize the annotations of people from different environments. Family at home, teacher at the school, and doctors at the hospital could create and share annotations on the Internet. Moreover, people could create different visualizations of the data and share their own findings.

Analysis of long-term data can show the trend of problem behavior for each day, week and month, and show its relationship with contextual information. Building a community around each autistic can increase awareness and understanding of the specific traits of each individual.

Conclusions and Future Work

This work has proposed the use of mobile-phones technology to improve understanding of problem behavior in people with ASD. With further emphasis on the annotation and monitoring parts, we have developed a mobile application that can be easily customized for multi-modal annotations.

After doing this project, we can provide a series of recommendations for the exploration of similar applications:

- **Development.** There is a web platform called Google App Inventor that allows rapid prototyping through a block diagram without need of knowing Java. However, this platform is limited in many ways: a) it does not allow merging existing projects, b) the source code cannot be manually edited, and c) the content cannot be dynamically created by the user. Therefore, we recommend using more sophisticated development platforms such as Eclipse and Android SDK.

- **Annotations.** As discussed in this project, there are different types of annotation in terms of their duration. For the short-duration ones, we recommend making the annotation with just one button click that identifies both onset and offset. For the long-duration annotations, we recommend indicating the onset with one button click and the offset with a second button click. Moreover, it is important to understand the different events and establish if they can happen simultaneously.

- **Platform.** Mobile phones are easy to carry in terms of portability; however, the number of annotations types and the constraints of the environment may require the use of larger screens. In the context of classroom annotation, where mobility is very limited, we will explore the use of Samsung Galaxy Tablets.

To further develop this technology, we intend to continue working on the following topics:

- **Validation**. We want to make subjective and objective evaluation of the application to assess its usability and incorporate user's feedback.
- **Internet Synchronization.** As described before, we want to build an Internet portal where people can store, share, view and analyze annotations and monitored data.
- **Automatic Annotation.** We want to explore annotations triggered by physiological changes. In particular, we want to record contextual information when skin conductivity levels (indicator of arousal) are above certain threshold.

Although this paper has proposed a mobile application to better understand the causes of problem behavior, this technology could easily be extended to many other fields which require continuous monitoring and annotations. For example, the same application can be customized to analyze the stock market, to track money expenses or to monitor food calories.

References

Carr, E. G. and Smith, C. E. (1995), Biological setting events for self-injury. Mental Retardation and Developmental Disabilities Research Reviews, 1: 94–98.

Goodwin M.S., Intille, S.S., Albinali, F. & Velicer W.F. (2010). Automated Detection of Stereotypical Motor Movements. Journal of Autism Developmental Disorders.

Hayes, R., Gardere, L.,Abowd, G., & Truong, K. (2008). CareLog: a selective archiving tool for behavior management in schools. In CHI '08: Proceeding of the twenty-sixth annual SIGCHI conference on Human factors in computing systems, 685-694.

Kientz, J., Arriaga, R.& Abowd, G. (2009). Baby steps: evaluation of a system to support record-keeping for parents of young children. Conference on Human Factors in Computer Systems. 1713-1722.

Morris, R., Kirschbaum, C. R., & Picard R. W. (2010). Broadening accessibility through special interests: a new approach for software customization. In *Proceedings of the 12th international ACM SIGACCESS conference on Computers and accessibility* (ASSETS '10), ACM, New York, NY, USA, 171-178.

Tomchek S.D. and Dunn, W. (2007). Sensory processing in children with and without autism: a comparative study using the short sensory profile**.** American Journal of Occupational Therapy, 61(2), 190-200.

Turner, M.(1999). Annotation: Repetitive Behaviour in Autism: A Review of Psychological Research. Journal of Child Psychology and Psychiatry, 40 (6), 839–849.