The Pika Pen

pika: (Japanese) sparkling, electric, light

Problem Description and Project Summary

Handwriting is one of the core skills needed for communication and is vital for children's early academic success and self-confidence [1]. Most of us take handwriting for granted, but many people have difficulty learning it in the first place. One such demographic are those faced with autism [2]. According to the Centers for Disease Control and Prevention, autism is estimated to affect 1.5 million Americans today (about 1 in 110 American children) [3]. Our Big Idea is to develop an innovative sensor-rich pen (*Pika Pen*) as shown in Figures 1 and 2. It will allow children with disabilities to improve their handwriting both alongside occupational therapists and independently.

Recent research conducted by the Kennedy Krieger Institute suggests that poor handwriting in children with autism may be improved by training of fine motor control [2]. Through many interviews with four independent occupational therapist partners, we have identified three indicators of poor handwriting: improper pen tip pressure, grip pressure and the inclination angle of the pen. Since autistic children struggle with a sensory problem [4], we believe they can learn to self- regulate these actions if they are provided with proper sensory feedback. A similar approach is evident in the new *ilimb* hand prosthesis, developed by *Touch Bionics*, which indicates grip force via a tactile vibration motor.

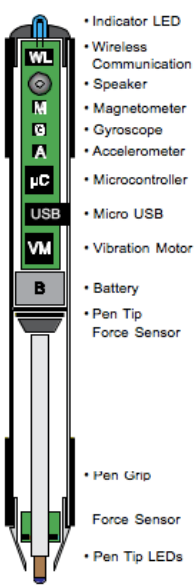

Figure 1: Potential design of Pika Pen showing feature set.

Products to improve handwriting currently exist, but are limited to low-tech weighted pens or pens with different shapes (*PenAgain*) that do not provide any feedback. Training software like *PointScribe* also exists, but is cost prohibitive. Currently there is no commercial pen device that measures inclination angle, and precise measurement of pen tip pressure is not feasible during actual writing with existing devices. For example, one method of estimating pen tip force used by our occupational therapists involves visually inspecting the deflection of a foam pad. Another similar method assigns a number between 1 and 4 corresponding to surface pressure, which depends on the number of stacked carbon papers that show a writing trace [5]. One of the current smart-pens on the market today is *LiveScribe,* which has embedded sensors and a microprocessor, but is primarily targeted for voice recording and note-taking. Research performed with force feedback/haptic devices shows great promise, but requires a large, dedicated, and costly setup like the *Phantom Omni* [6]. Based on our research and close discussions with our occupational therapist partners, we will develop a pen that contains the necessary sensors and bio-feedback indicators. Specifically, we intend to include tip and grip force sensors and an IMU (Inertial Measurement Unit). Similar to the *Nintendo Wii* controller, which contains an IMU to estimate orientation, we will measure the pen's inclination angle θ, as shown in Figure 2.

For the bio-feedback indicators, we will include LED indicator lights, a vibration motor, and a speaker. By selecting different modes, the sensed handwriting information can then be conveyed real time to the user in three ways: visually, tangibly, and audibly. For example, the LED indicator light can change color and intensity to indicate correct pen tip force, as shown in Figure 3. Figure 1 shows how all these features might be packaged into the final product.

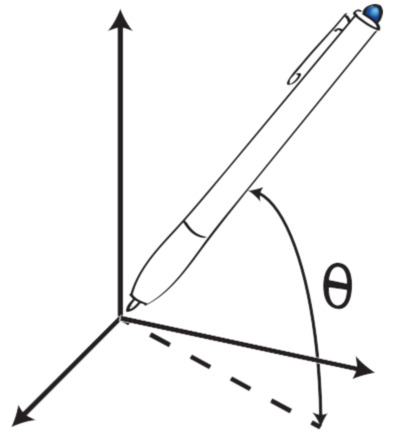

Figure 2: Inclination angle θ measured bv an IM

In developing *Pika Pen* we will focus on four goals; it should be convenient and intuitive so that the child may improve independently from a trainer; it should be sold at a lower cost than other devices so that access issues are reduced; it should also have wireless data logging capabilities so that progress can easily be tracked and the data can be used for later analysis. Finally, it should be aesthetically appealing and fun to use. In this way, we hope that the children can improve their handwriting faster and more cost-effectively than the aforementioned methods.

Our pen has LED indicator lights and a *Flexiforce* sensor to detect pen tip force. We found that a small group of autistic children who used this early prototype to write a sentence were able to regulate the pin tip pressure within some bounds. The two instances where the spikes in measured force exceeded the bounds occurred at the divisions between words.

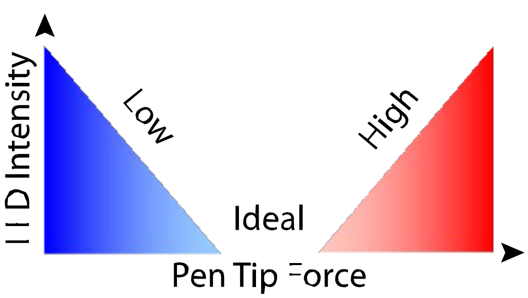

Figure 3: Pen tip force indicating mode where two LED's communicate the ideal force. Different colors and intensity indicate direction and amount of force applied.

If we are fortunate enough to be selected as a Big Ideas winner, we will use the award money to develop a more complete prototype. In the long-term, we have definite plans to patent our idea, seek FDA approval, and investigate manufacturing and distribution partners. However, at this stage we need funds to purchase the individual components (force and orientation sensors, microcontrollers, and bio-feedback devices), develop the software (orientation estimation, wireless communication, data logging, etc.), and design the physical body of the first release of *Pika Pen*. Part of our initial expenses will also include the electronics manufacturing and rapid prototyping costs, as well as the overhead necessary for travel to our occupational therapy partners for beta testing.

We plan to complete development by the end of October 2012, at which point we will transition into in-house testing. After testing and refinement of our design, we plan to perform final beta tests and seek high volume manufacturers. More details are available in the Timeline section.

We also feel that the potential of *Pika Pen* to improve handwriting is not just limited to the autistic population. Contingent upon the success of our initial designs, we are confident that both the target population as well as the problem task can be scaled up with this device. For example, approximately 14% of people around the world are victims of stroke [6]. Many undergo mild strokes and retain most of their coarse motor control, but their fine motor control – including handwriting skills – may have deteriorated. This group of people may appreciate a convenient option to retrain their handwriting or other diminished motor skills without the high costs associated with physical therapy. Our team is excited about the potential benefits that our *Pika Pen* may provide to society and we look forward to scaling up this Big Idea for the future.

Team Biographies

Team Lead (Mechanical Engineering, Graduate Student): Project Director
[Name] has experience in many rapid prototyping projects such as a heads-up-display for urban fire-fighters, intelligent electronic power steering systems, and inertial appendage assisted terrestrial robotics and is well suited for guiding this committed research team.

Student A (Mechanical Engineering, Graduate Student): Management
[Name] was the team leader of the UC Berkeley Formula SAE team for 2 years, guiding the design and construction of a small formula-style race car. She is skilled at managing budgets, logistics, and communications, and will be perfect for keeping this team on track.

Student B (Mechanical Engineering, Graduate Student): Controls & Sensor Fusion
[Name] has led several technical projects and has performed extensive research in control & sensor fusion algorithm design and implementation on several platforms, ranging from simple mechanical systems to complex multi-axial industrial robot manipulator.

Student C (Mechanical Engineering, Graduate Student): Hardware Design
[Name] has taken lead roles on projects dealing with mechanical, electrical, software, and control design. Project sizes have ranged from many successful one-offs to a large scale manufacturing of a fleet of floating sensors participating in a wireless sensor network.

Student D (Mechanical Engineering, Undergraduate Student): Electronics
[Name] has experience in printed circuit board manufacturing, circuit board design, and rapid- prototyping using 8-bit microcontrollers.

Student E (EECS, Undergraduate Student): Software
[Name] has experience in rapid-prototyping design and programming in multiple languages. He is also familiar with software such as SolidWorks, EAGLE, and MATLAB.

References

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