Ubiquitous and Mobile Computing CS 403x:

Using Mobile Phones to Write in Air

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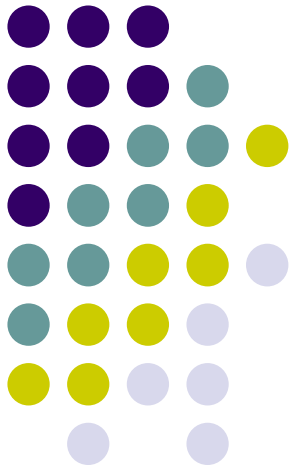
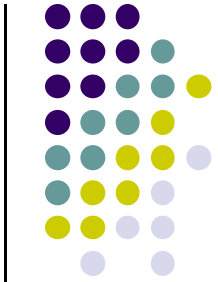


Introduction

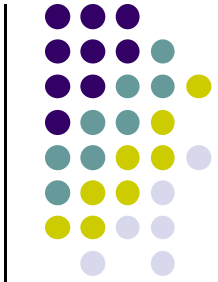
- Use built-in accelerometer in modern mobile phones as an easy and ubiquitous way of capturing short written information

Alternatives



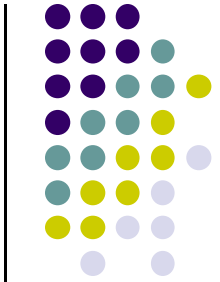
- Text to speech
  - They argue that it was difficult to process speech (2011)
- Physical Typing

Motivations



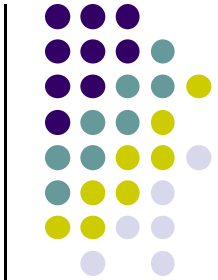
- Typing SMS is hard for a moderate section of society
- Studies show discomfort when typing
  - Small key sizes
  - Short inter-key spacing
  - Need for multi-tapping

Objectives



- Explore the viability of using the mobile phone accelerometer to write in the air
- Characterize the nature of the challenges and propose a multi-phase approach to recognize alphabets and words
- Prototype the PhonePoint Pen (P3) on Nokia N95s, and test it with 10 student users and 5 hospital patients

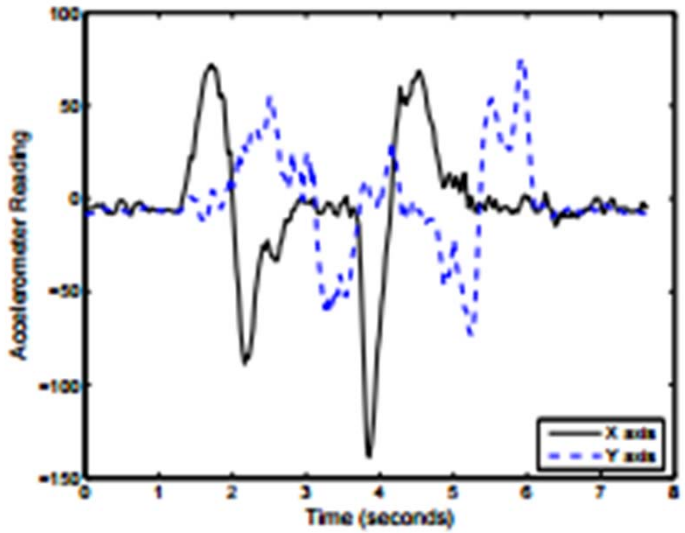
Use Cases



- Make reminder at stoplight
- Walking
- Assistive Communications for Impaired Patients
- Equations and Sketching
  - Difficult to write equations with standard phone keyboard
- Emergency Operations and First Responders
  - Typing and talking on phone difficult when engaged in critical situations
- Creative Actions
  - Write “CNN” and TV changes channel to CNN

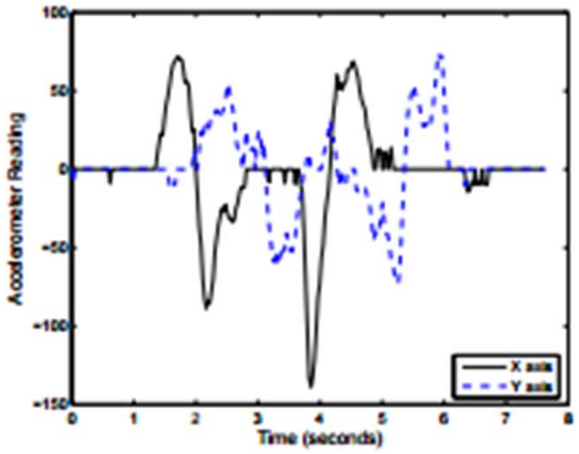
Challenges

- Lack of Power - 2011
- Filtering out rotation without gyroscope - 2011
- Unknown movements such as repositioning
- Noise in mobile phone accelerometers



Solutions

- Filtering Rotation - Force user to write without rotating phone
- Phone Displacements - Users were asked to briefly pause between strokes while writing letters
- Accelerometer Noise - refining it through simple numerical and signal processing algorithms



Methodology

- Alphabet character is distinguished as a series of Strokes
- Each stroke identified by getting correlation between ideal stroke and human stroke

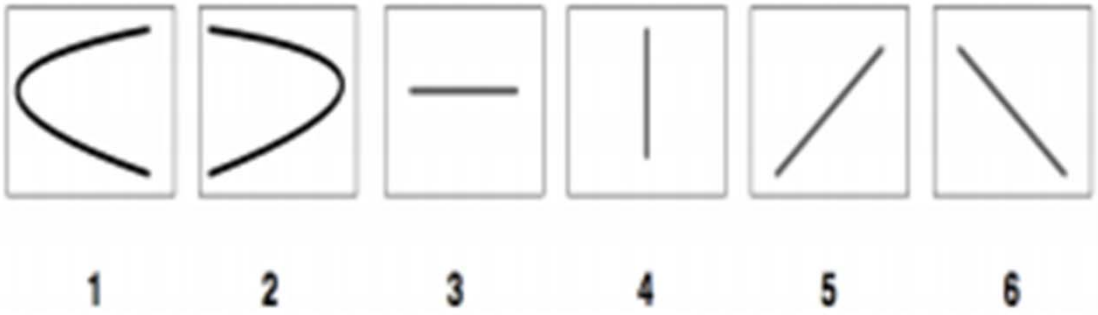
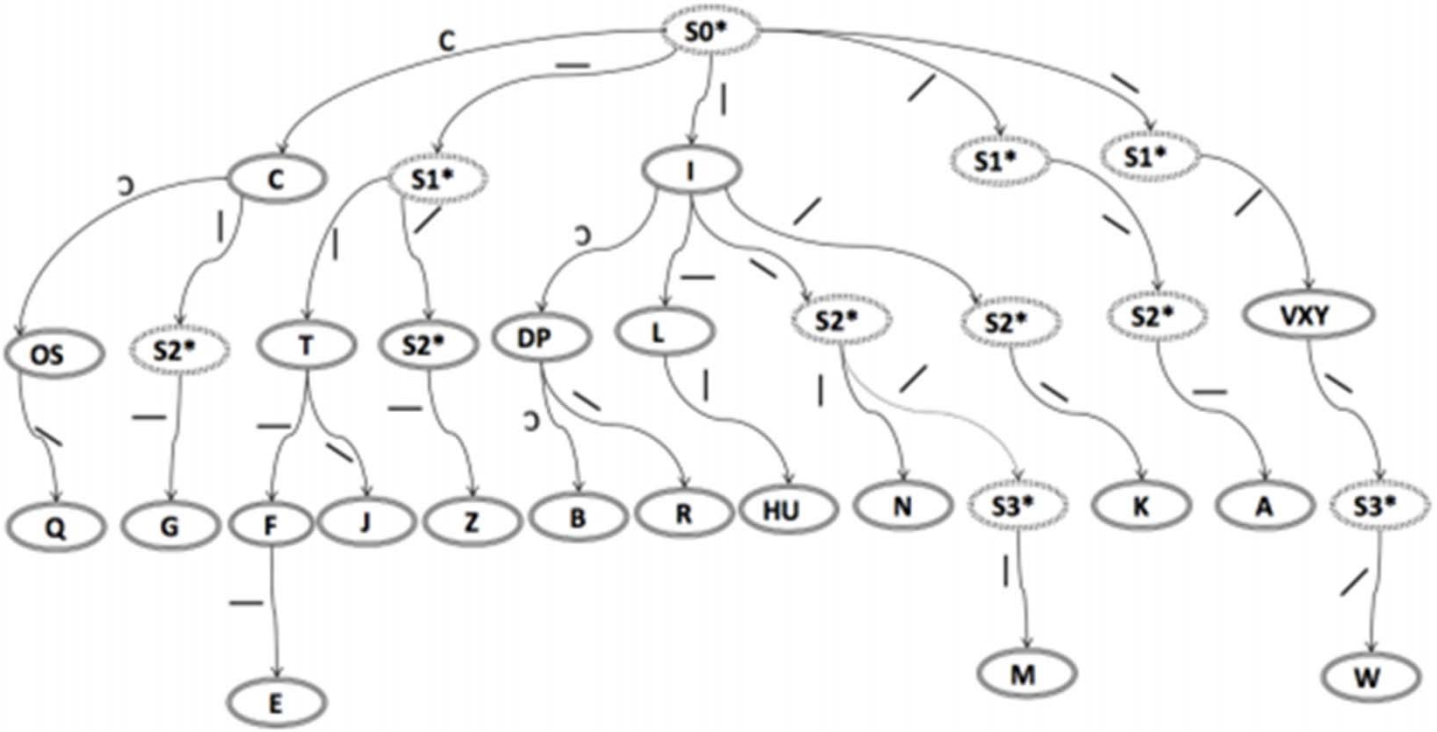


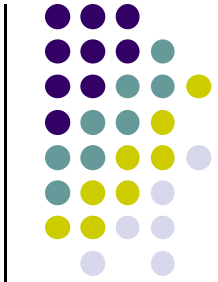
Figure 4: Basic strokes for English characters.

Methodology Cont.

- English Characters identified using Stroke grammar in the form of a tree



Methodology Cont.

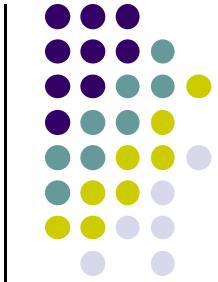


- Spelling Correction implemented to help identify words
  - Uses standard “edit distance” approach to identify words
  - Also accounts for commonly misinterpreted letters to increase word confidence
- Control Gestures
  - Inserting Space: horizontal movement, or two dots
  - Deleting Character: shake four times briskly
  - Send email: draw a checkmark

Implementation

- Used matlab libraries for processing accelerometer readings
- Prototyped code in Python for on-phone processing
- Users wrote with phone, output shown on screen

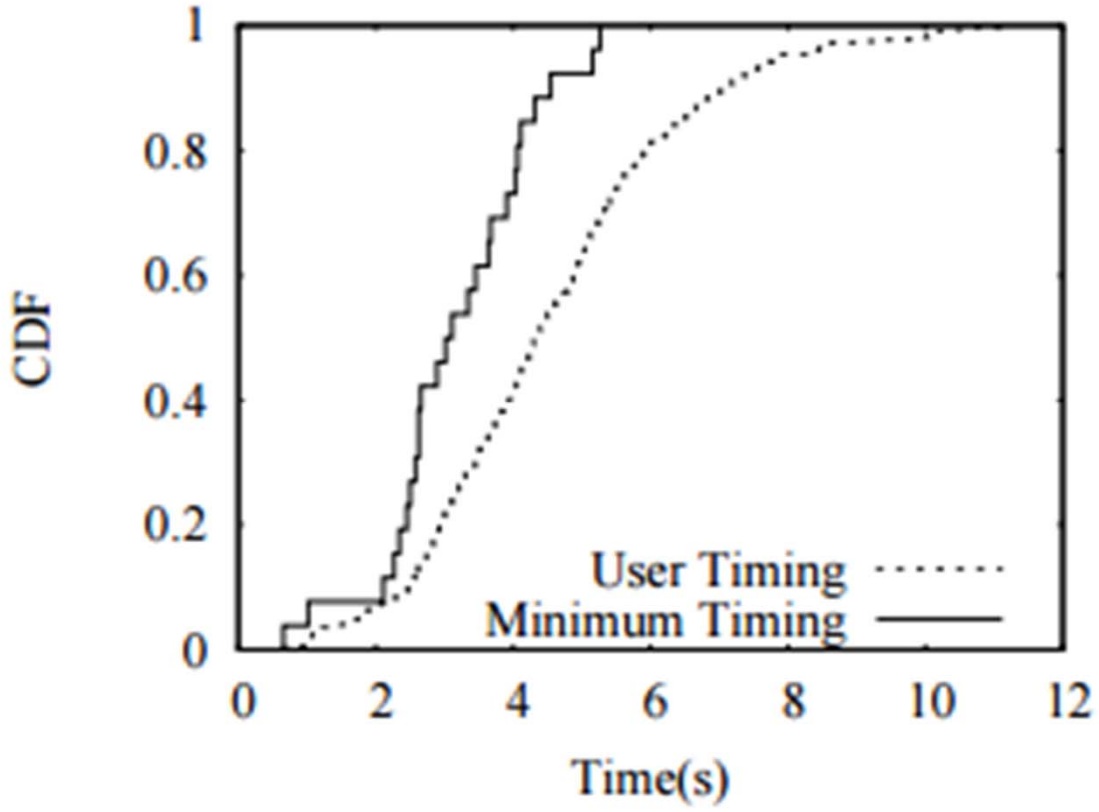
Metrics and Testing



- Evaluation Metrics centered around
  - Writing Speed
  - Character Recognition Accuracy
  - Human Readability Accuracy
- 10 students, 5 hospital patients

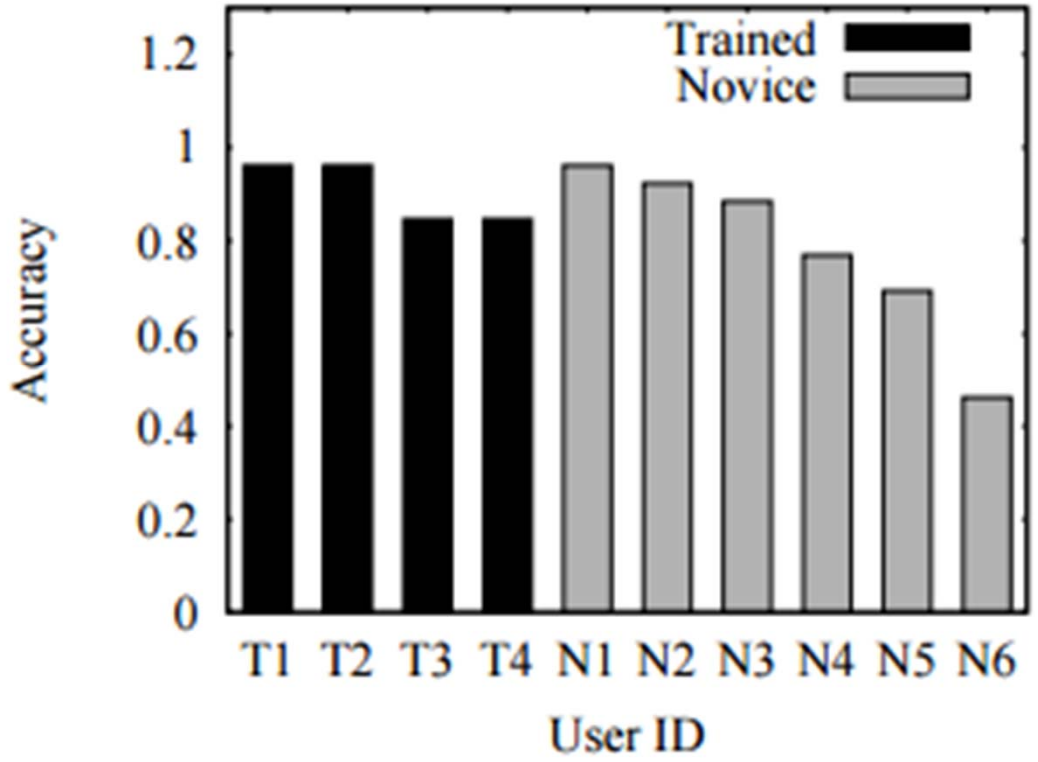
Results - Writing Speed

- Average character writing time is between 3.02 to 4.3 seconds



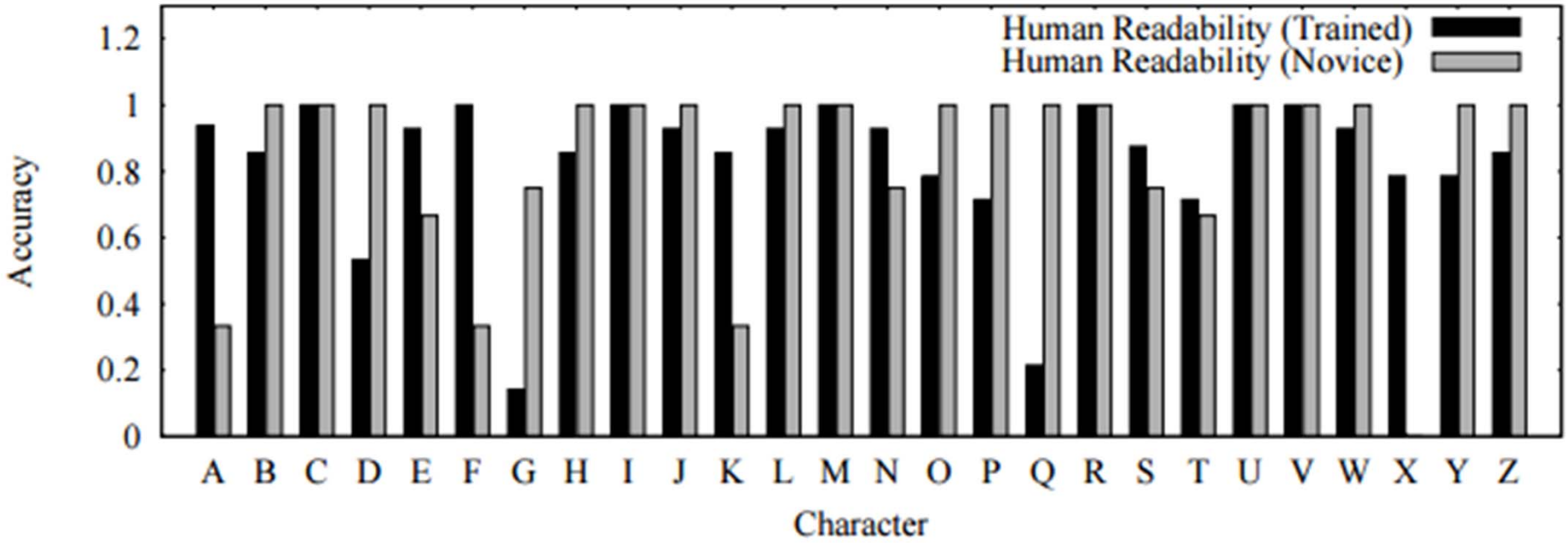
Results - Character Recognition Accuracy

- With 3-4 minute user practice, average character recognition of 91.9% and 78.2% for trained and novice

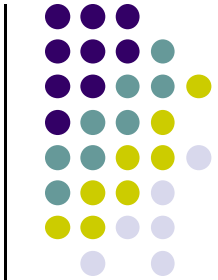


Results - Human Readability Accuracy

- Average readability is 83% and 85.4% for trained and novice writers respectively

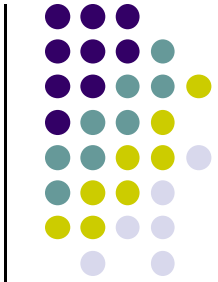


Limitations



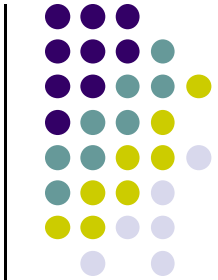
- Quicker writing
- Need to pause between strokes/chars
- Long words
- Drawing pictures
- Cursive handwriting
- Writing while moving
- Better testing population
  - Mostly tested on engineering students, who may have adapted to the tech
- Better Algorithms

Related Work



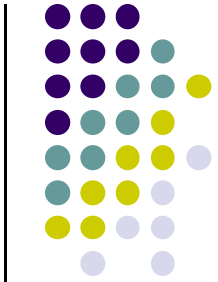
- uWave
  - Accelerometers
  - Gesture with mobile phones to authenticate, open/close apps, etc
  - 99% accuracy with 8 gestures and negligible training
- TinyMotion
  - Vision based
  - Uses built in camera to detect cell phone movement
- ‘Write in air’
  - Vision based, Microsoft project
  - Cameras track an apple that is used to air-write alphabets

Related Work (cont.)



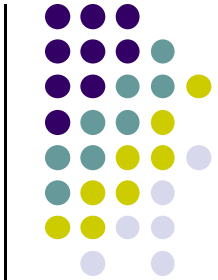
- SketchREAD
  - Stylus based sketch recognition
  - Electrical diagrams and family trees
- Electronic Cocktail Napkin
  - Stylus based sketch recognition
  - Sketching environment that could identify sketches
- Unistrokes
  - XEROX
  - Maps a special gesture alphabet to english
- Logitech Air Mouse
  - Mouse like functionality but held in air
- SmartPen and SmartQuill
  - Use any surface for writing

Conclusion

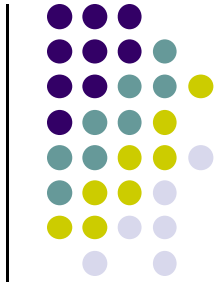


- Make use of accelerometer in mobile phones
- Goal was to use phone as a pen
- Negligible Practice
- Can run on phone's processor due to algorithm simplicity
- Message is displayed on screen and can be emailed
- Performance results and user feedback are positive

References



- *Using mobile phones to write in air* Sandip Agrawal, Ionut Constandache, Shravan Gaonkar, Romit Roy Choudhury, Kevin Caves, and Frank DeRuyter, in Proc. MobiSys 2011

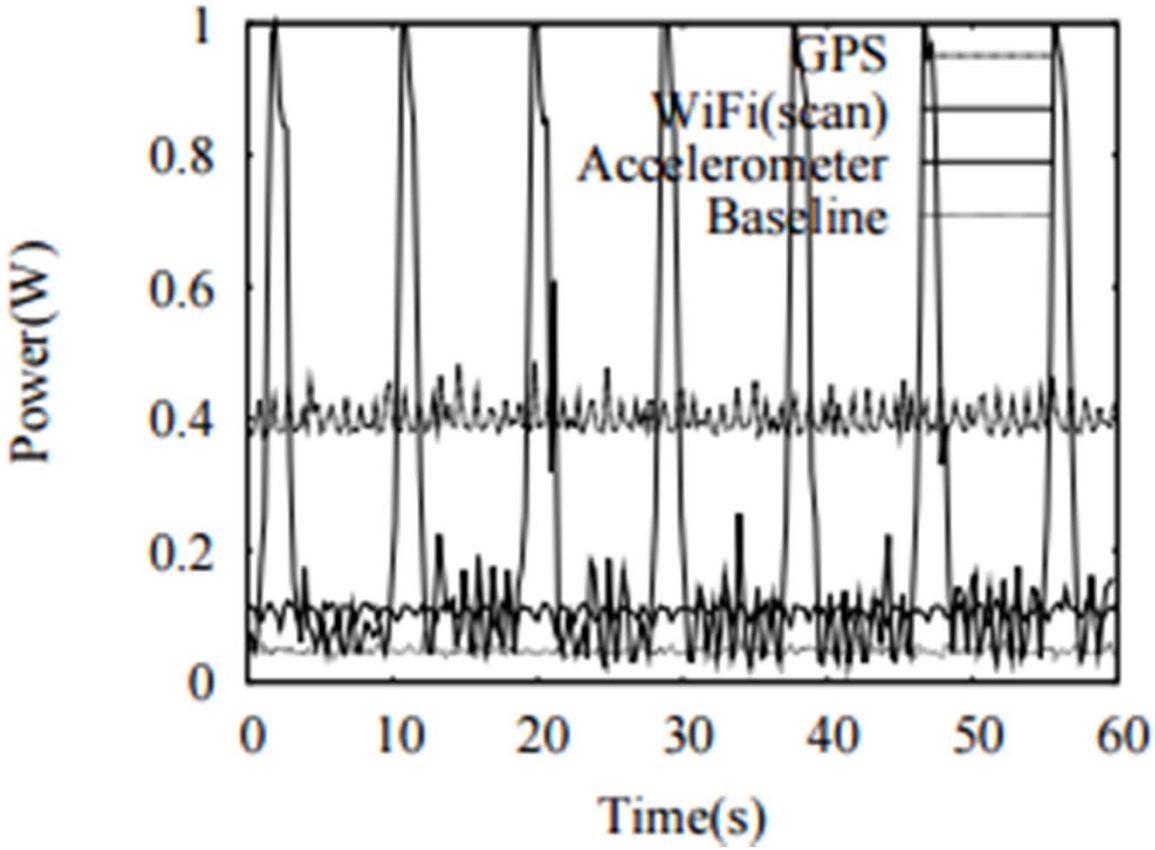


Word Length	Phone Pen	Spell Correct	P3-Aware Spell Correct	Human Readable
2	17/20	19/20	20/20	11/20
3	18/20	19/20	19/20	12/20
4	13/20	18/20	19/20	10/20
5	13/20	16/20	17/20	14/20

Word Recognition

Table 3: Patient performance.

Patient ID	1	2	3	4	5
Accuracy	1/8	1/8	1/8	5/8	could not press button


GPS
WiFi(scan)
Accelerometer
Baseline
Power(W)
Time(s)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60