Intelligent Device Applications for Real-Time Characterization of Cognitive Loading: *The Implications for Distracted Driving*

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Motivating Hypothesis

- Biometric texting patterns, indicative of cognitive workload, can be measured in-situ …….
- …….These “signatures” may allow for the identification and mitigation of distracted vehicle operators.

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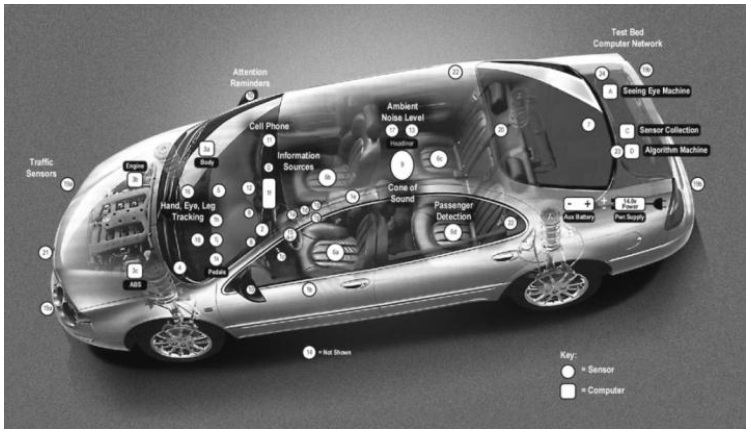
Background Context and Challenges

- **“…..the test-bed vehicle was outfitted with almost every sensor conceivable.”** Pompei JF, et al. 2002, An Automobile-Integrated System for Assessing and Reacting to Driver Cognitive Load.

- Examples of relatively recent countermeasures.
  - “Key2SafeDriving”
  - iZup by Illume Software Inc.
  - ZoomSafer by ZoomSafer Inc.



Pompei JF, et al., 2002.

How does a "Distracted Texter" behave?

- Consider the Following

  Texting ~~*Driver*~~ distraction is the voluntary or involuntary diversion of attention from the primary **texting** ~~*driving*~~ task not related to impairment (from alcohol, drugs, fatigue, or a medical condition) where the diversion occurs because the **texter** ~~*driver*~~ is performing an additional task (or tasks) and temporarily focusing on an object, event, or person not related to **texting** ~~*driving*~~. The diversion reduces a **texter's** ~~*driver's*~~ situational awareness, decision making, and/or performance resulting, in some instances, in a collision or near-miss or corrective action by the **driver** and/or other road user.*

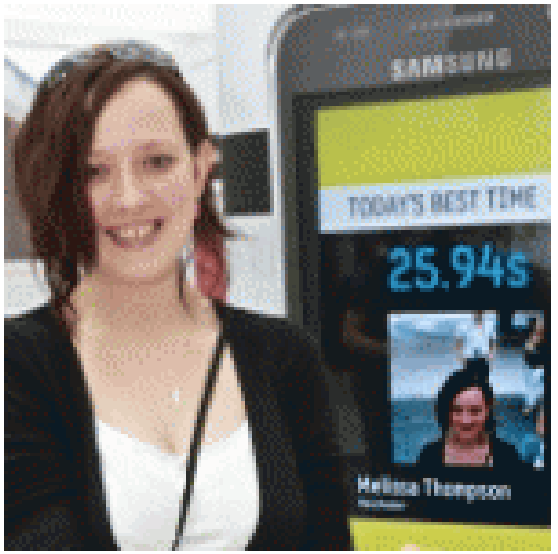
*Adapted from the Australian Road Safety Board, definition of a distracted driver, 2006.

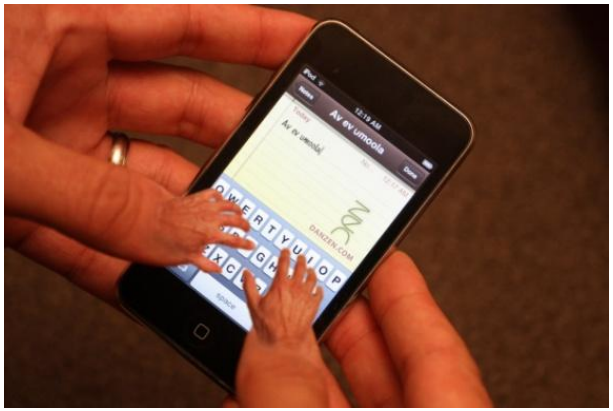
How Fast Do People Text?

- Melissa Thompson of Manchester, England
- The world's fastest texter……August 23, 2010.

"the razor-toothed piranhas of the genera Serrasalmus and Pygocentrus are the most ferocious freshwater fish in the world. In reality they seldom attack a human."

- Melissa texted this **160 character** message in just under **26 s** or at a keystroke frequency of about **6 Hz !**





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Nokia 6790 Surge®

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Application

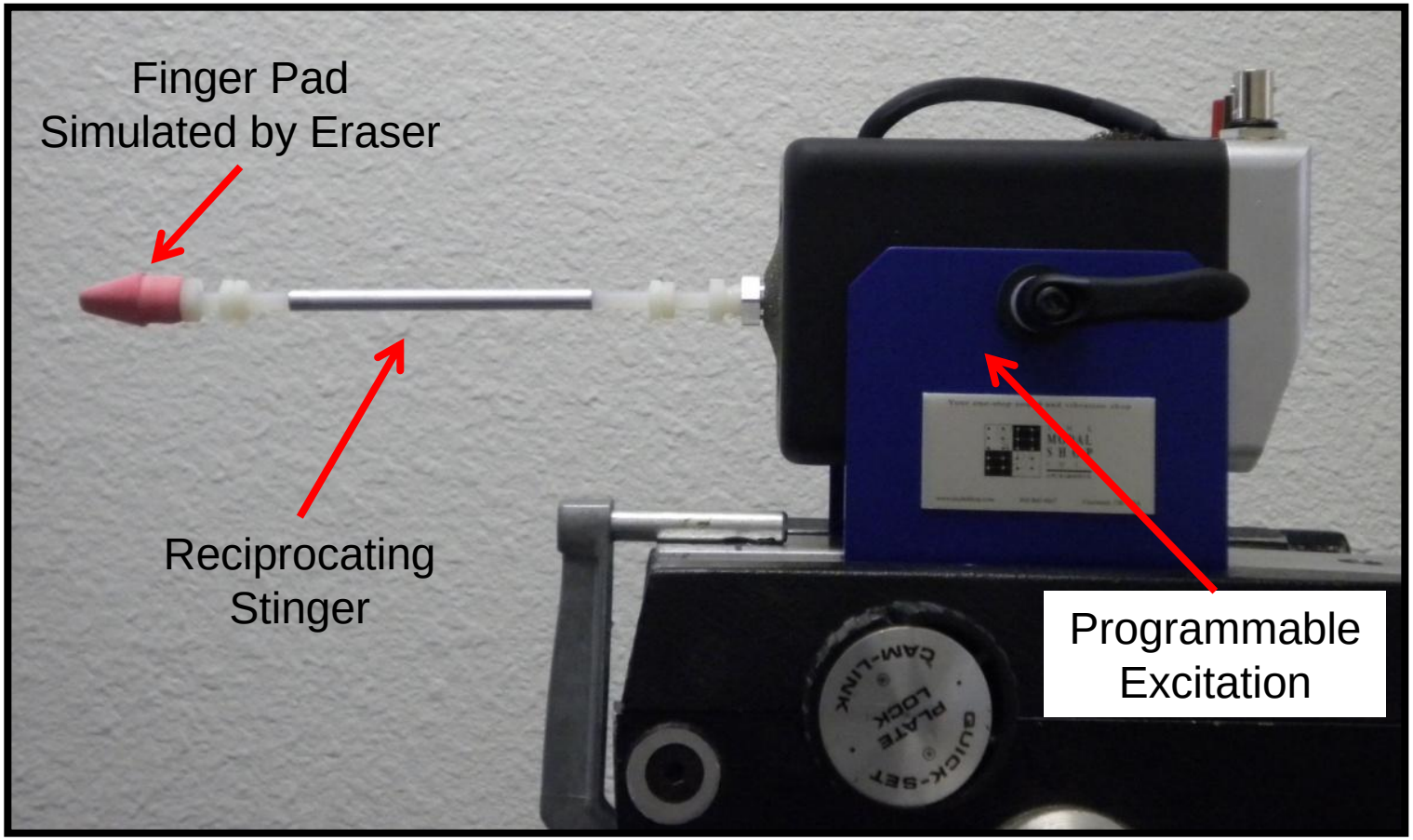
- Data logging runs in the background.
- User operates the handset in a normal fashion.
- Application logs both key down and key up events with timestamps.
- Data are stored in a file to be analyzed later.
- Prototype application installed on a Nokia 6790 Surge.

Logging Function – Baseline Characterization

- User key depression was simulated by using a reciprocating piston.
- The handset was held in a fixed position using a small vise clamp.
- Data acquisition was initiated and allowed to run in the background.
- A selected key was repeatedly depressed at a fixed frequency.
- Several frequencies, reflecting the dynamic range of users, were used.
- The logged data were downloaded to a PC for analysis.

Characterization of Logging Function

- Method of Key Actuation.



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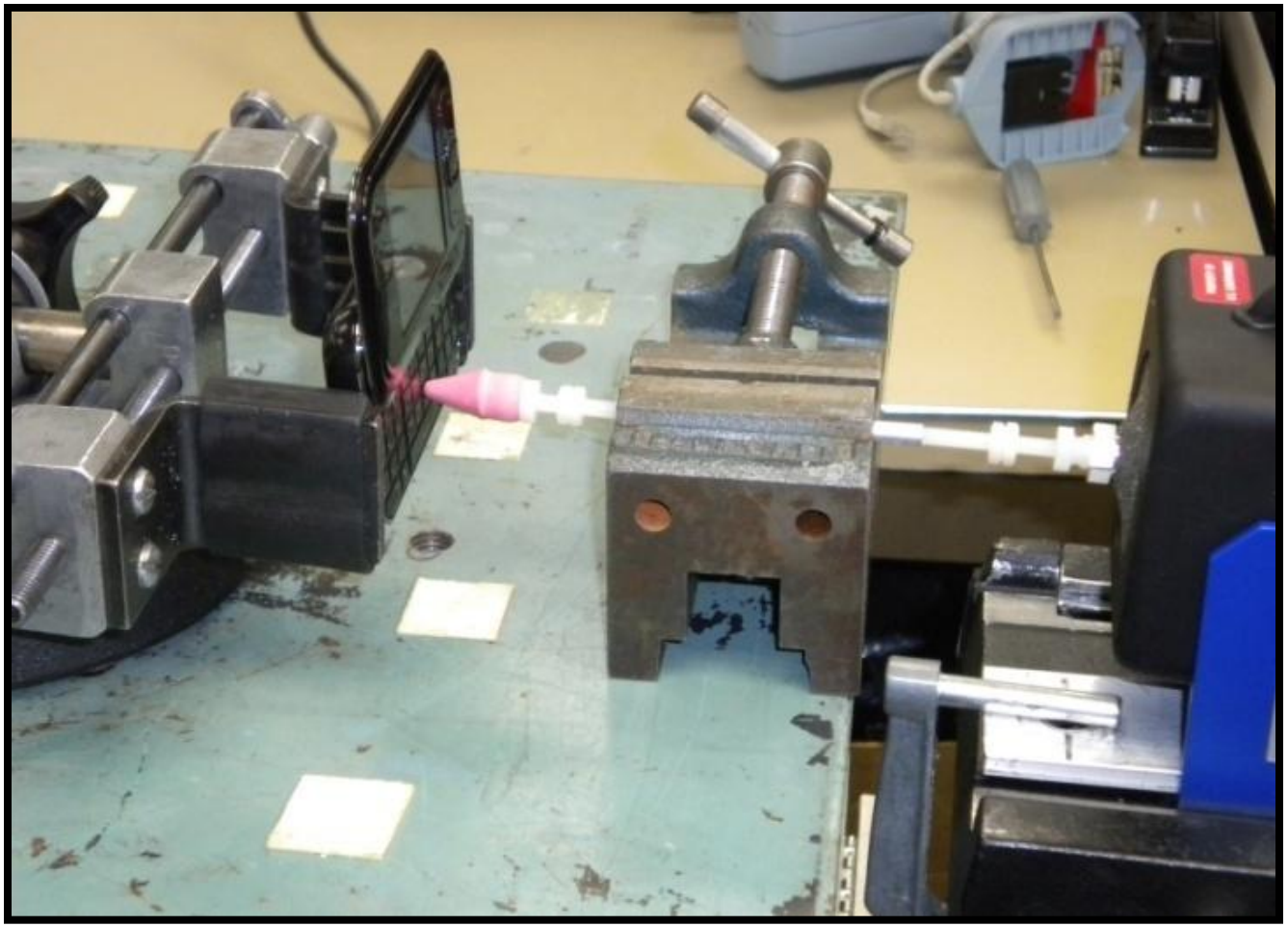

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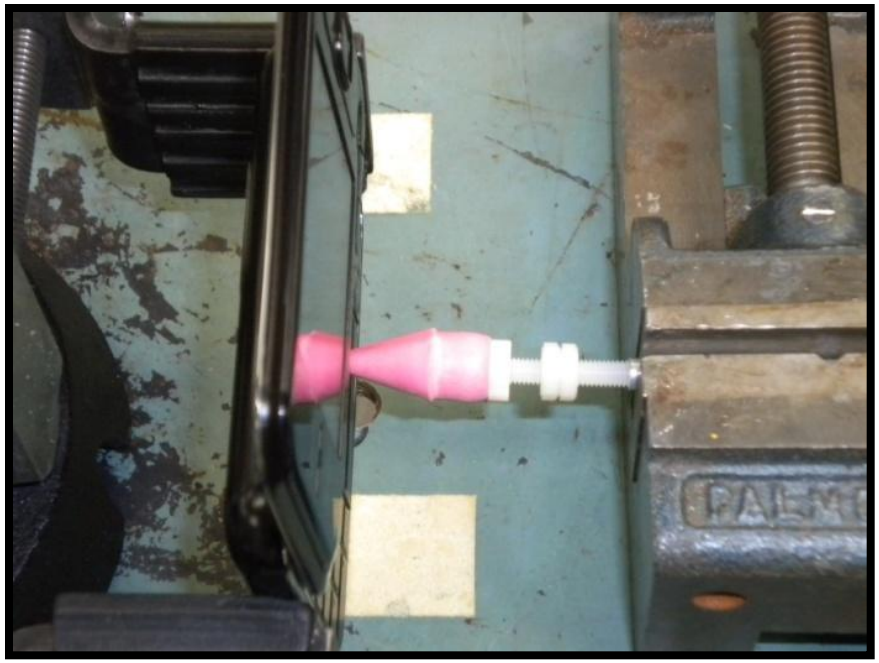
Characterization of Logging Function

- Method of Key Actuation.
  - Sinusoidal pulses were used to excite the key at frequencies of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 20 Hz



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Example of Data

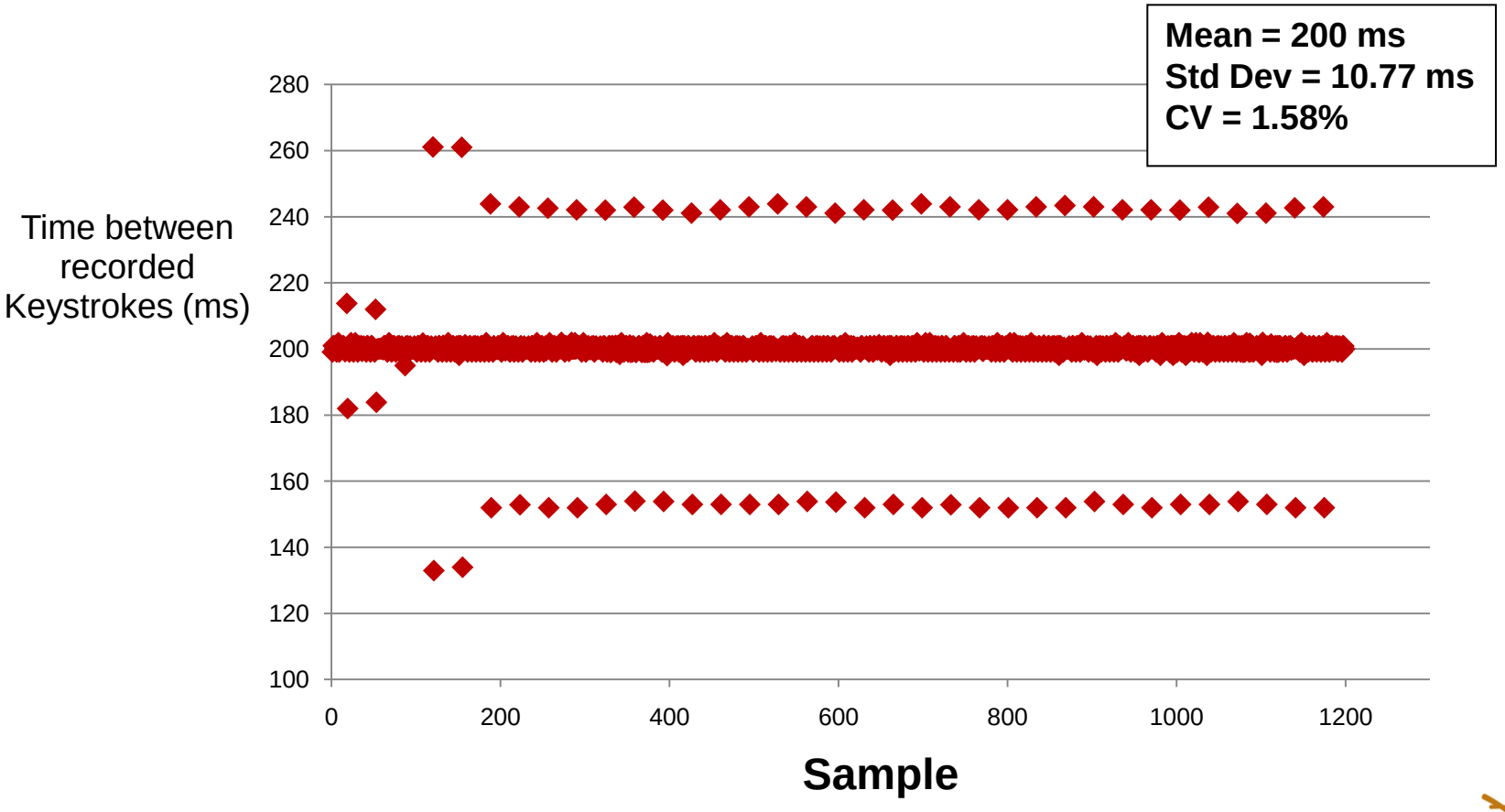
- Repeated key actuation at 5 Hz (period = 200 ms)
  n = 100, CV = Coefficient of Variation.

Key Code	Event Type	Time Stamp	Delta (ms)
68	Down	63449802447537000	199
68	Down	63449802447736100	200
68	Down	63449802447936100	201
68	Down	63449802448137000	200

Mean = 200 ms
Std Dev = 3.16 ms
CV = 1.58%

Example of Repetitive Key Strokes Data

- 5 Hz excitation (period = 200 ms).



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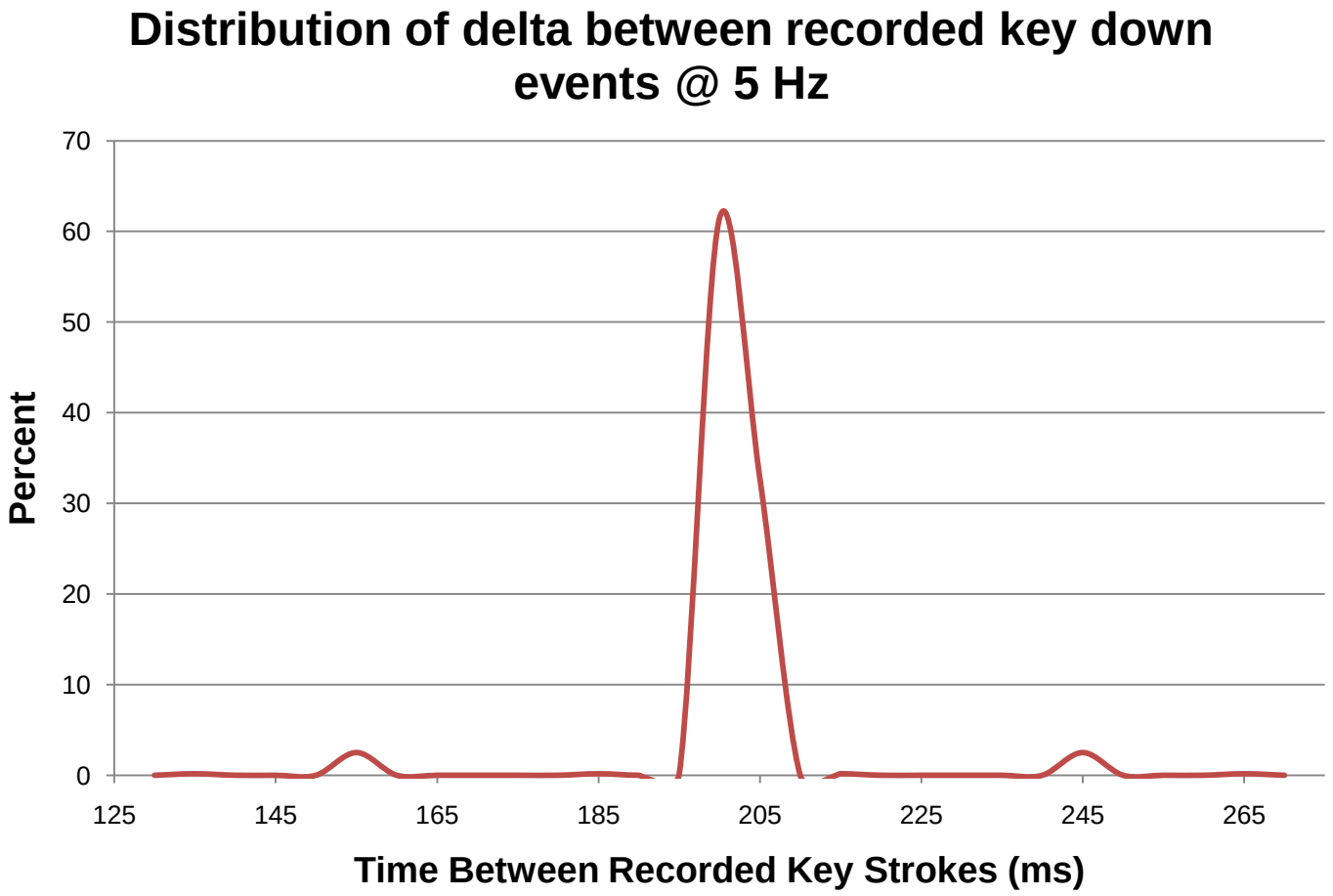

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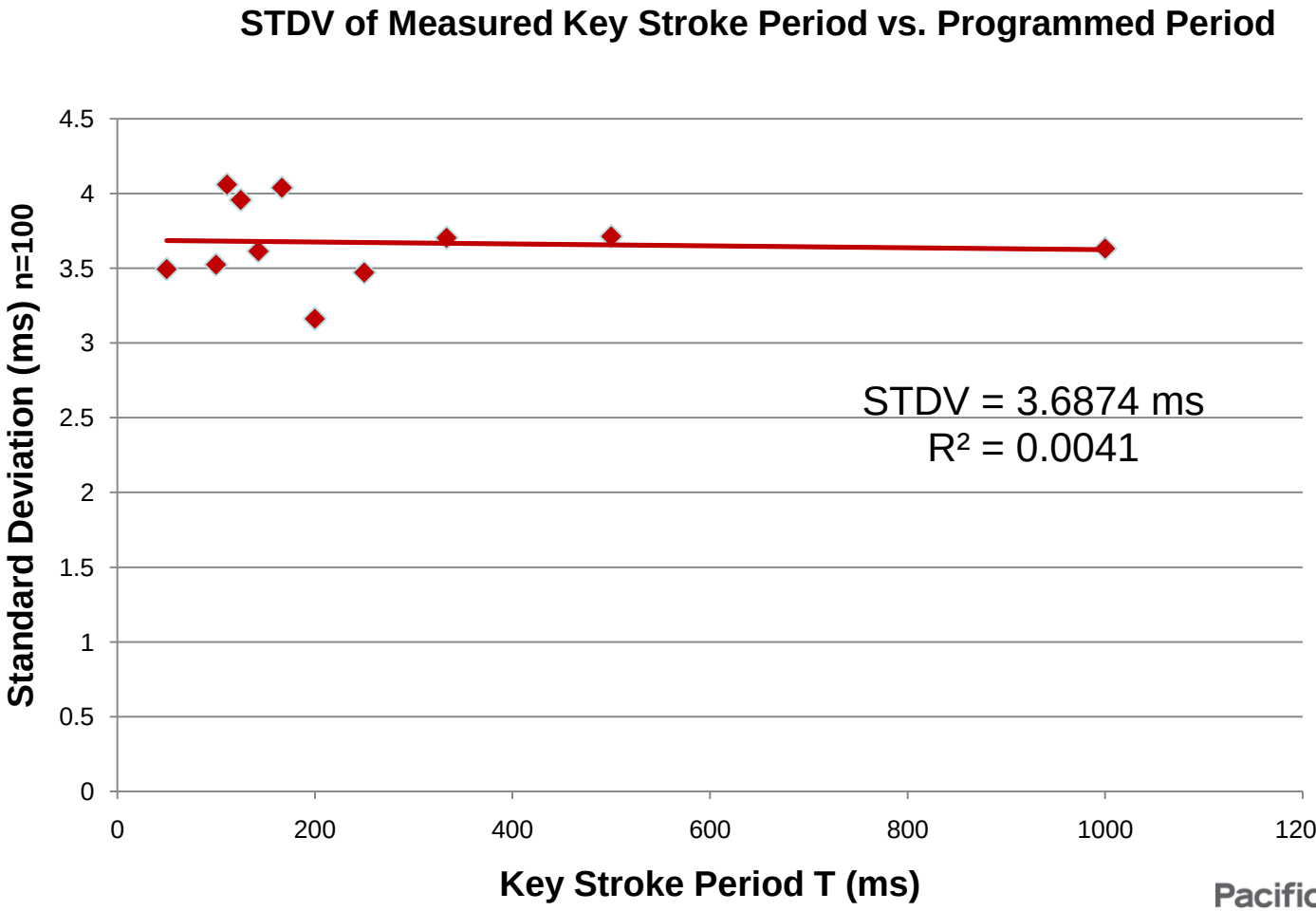
Example of Repetitive Key Strokes Data

- 1 – 20 Hz excitation (period = 1000 – 50 ms).



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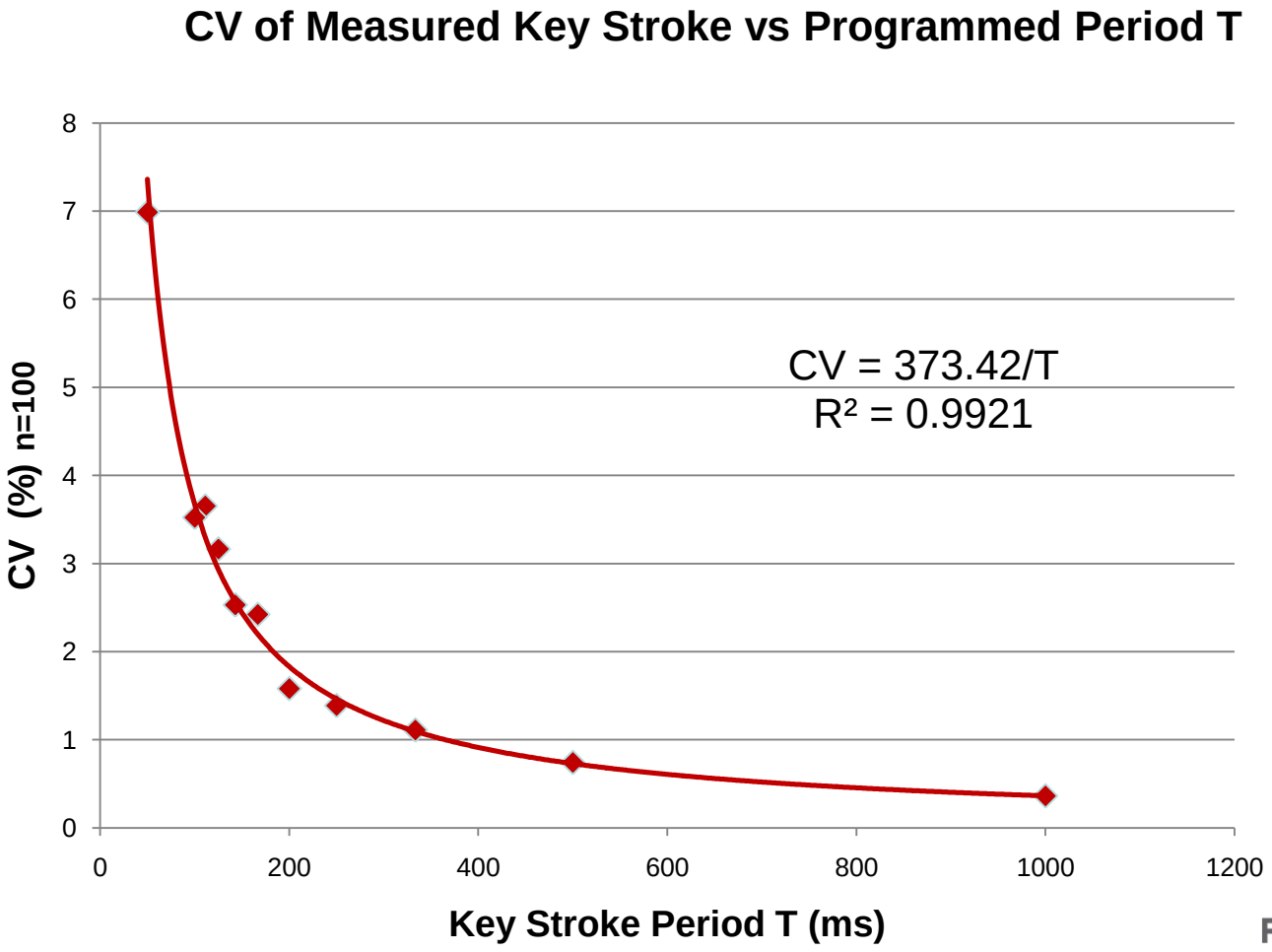

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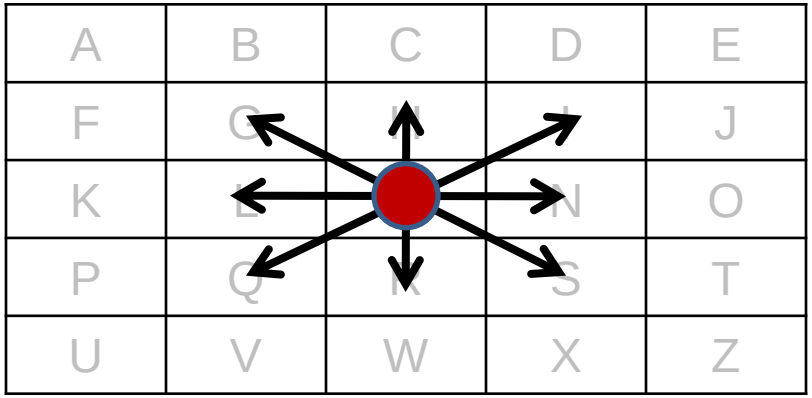
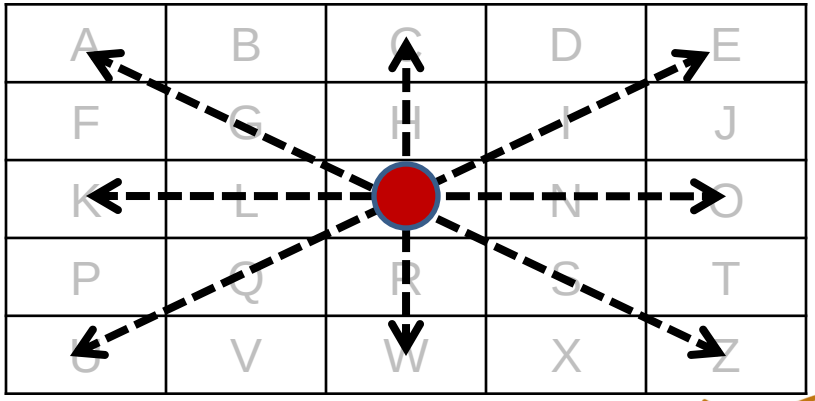
Biometric Digraph Convention for Users

1. **Horizontal Digraph**: time between horizontally adjacent keys.
2. **Vertical Digraph**: time between vertically adjacent keys.
3. **Diagonal Digraph**: time between non-adjacent diagonal keys.
4. **Non-Adjacent Horizontal Digraph**: time between non-adjacent horizontal keys.
5. **Non-Adjacent Vertical Digraph**: time between non-adjacent vertical keys.
6. **Non-Adjacent Diagonal Digraph**: time between non-adjacent diagonal keys.
7. **Error Rate**: use of Backspace key, repeated keys, word length, extra spaces, etc.
8. **Key Hold Time**: time difference between pressing a key and releasing it.





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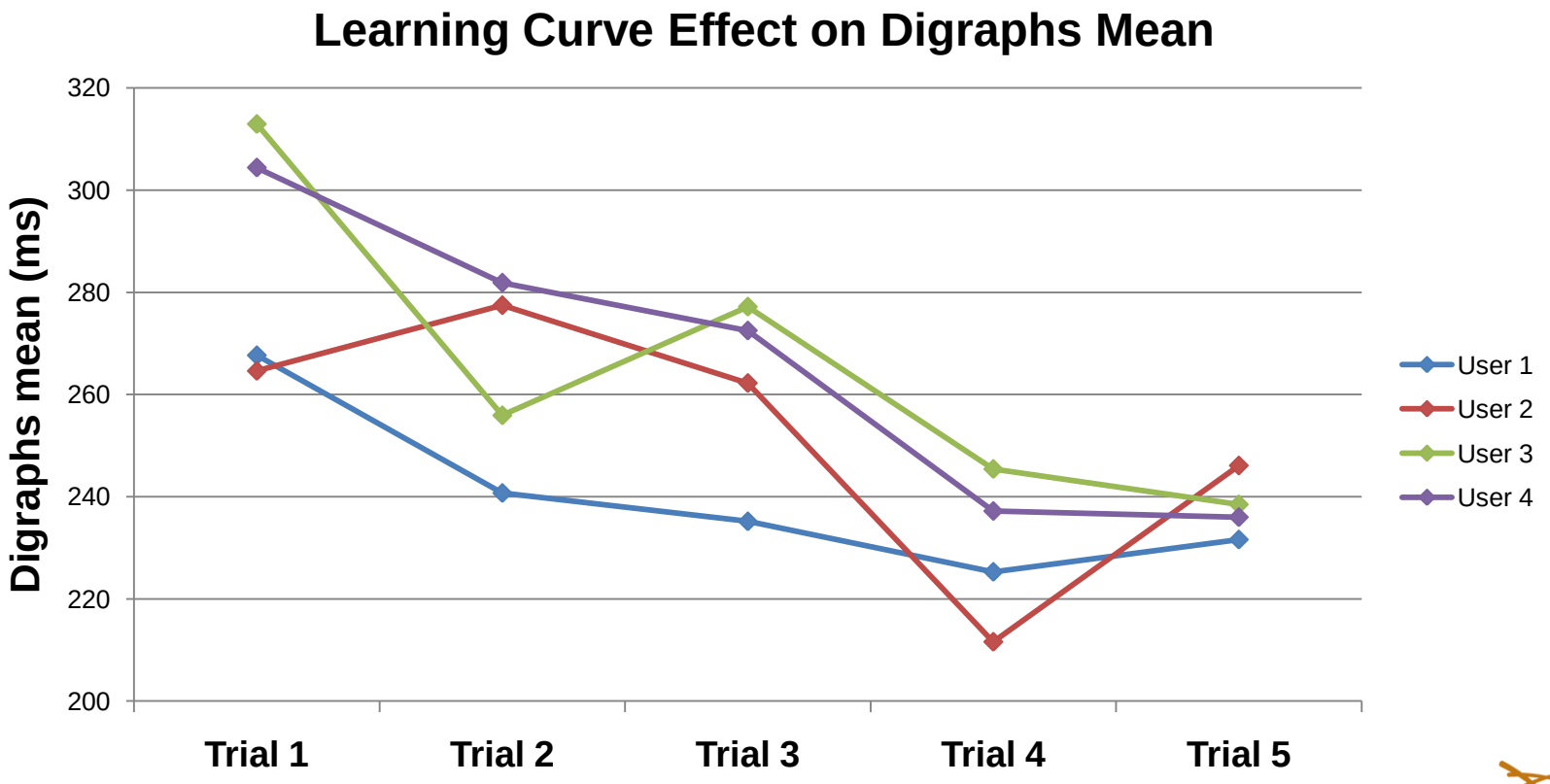
Example of User Data – Learning Curve

- Users typed message 5 times to reduce “learning curve” effect.
- Mean time between successive keystrokes is illustrated.



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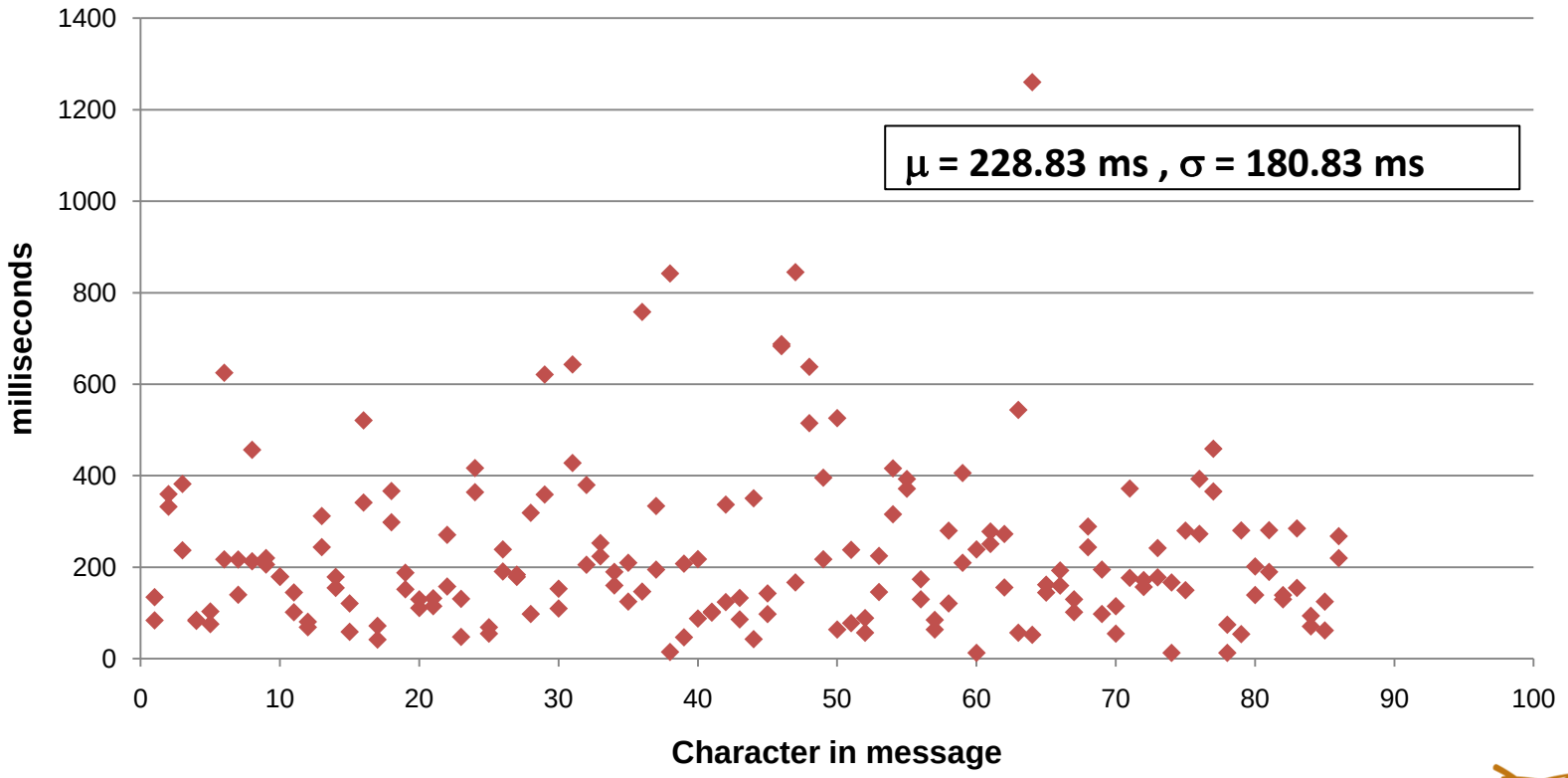
Example of User Data

- Scatter plot of digraphs for trials 4 and 5 for a user.



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Conclusions

- The prototype data logger has the required temporal resolution to capture user key stroke dynamics.
- Opportunity to gain new insights for naturalistic driving R&D.
- Potential for new distraction countermeasure.
  - Distinguish vehicle operators from passengers.
  - Adaptable and scalable to level of cognitive impairment.

Advantages

- Vehicle independent - functions for personal, mass transit and cargo vehicles.
- Device independent - implementable as a low-cost software application installed on cell phones.
- Eliminates the need for secondary in-vehicle devices.
- Viability of on-board real-time data analysis.
- Data logger can be integrated with other data acquisition systems via Bluetooth or other wireless data interface.