

Pairwise Variability Index: Evaluating the Cognitive Difficulty of Using Mobile Text Entry Systems

Frode Eika SANDNES

Faculty of Engineering

Oslo University College, Oslo, Norway

Hua-Li JIAN

Faculty of Arts

National Cheng Kung University, Tainan, Taiwan

Evaluating mobile text entry

- Performance oriented
 - Inter keystroke delays
 - Characters per second/minute
 - KSPC (keystrokes per characters)
 - ...
- Error oriented
 - Error rate
 - ...
- Cognitive
 - NASA TLX (task load index)
 - ...

Cognitive processing and typing rhythm

- Some relationship between typing speed, error rate and cognitive difficulty of typing task
- Duration of inter-keystroke delay related to cognitive processing load
- Regular typing rhythm -> cognitively balanced text entry strategy
- Use median based measures to avoid outliers – thought wonders and resting breaks

The pairwise variability index

$$pvi_i = \frac{|d_{i+1} - d_i|}{d_{i+1} + d_i}$$

Select the median of all the pvi_i values

The difference between two consecutive timestamps $d_i = b_{i+1} - b_i$

Experiment

- Subjects:
 - 3 volunteer undergraduate students at OUC
- Equipment:
 - Desktop computer with full keyboard, monitor, mouse
 - 5-keys pammed to keys a, s, d, f and [space]
 - Text entry implemented as apples, running in browser
- Procedure for each method
 - 5 minutes practice
 - 15 minutes typing session (source text on screen)
 - questionnaire
- Measurements
 - Timestamped keystroke events

3 multi-keystroke strategies

- Multitap (similar to old handsets)
- Tree-based
- One-stroke (similar to T9)

3 multi-keystroke strategies

Key-1: a, b, c, d, e, f

Key-2: g, h, i, j, k, l

Key-3: m, n, o, p, q, r

Key-4: s, t, u, v, w, x, y, z

Key-5: [break-key]

- Multitap (similar to old handsets)
- Tree-based
- One-stroke (similar to T9)
Characters retrieved by repeatedly pressing the key labelled with the desired character until it appear, then the break key.

3 multi-keystroke strategies

- Multitap (similar to old handsets)
- Tree-based
- One-stroke (similar to T9)

Step 1: Chose category

Key-1: a, b, c, d, e

Key-2: f, g, h, i, j

Key-3: k, l, m, n, o

Key-4: p-q, r, s, t, u,

Key-5: v, w, x, y-z, []

Step 2: Chose within cat.

Key-1: a

Key-2: b

Key-3: c

Key-4: d

Key-5: e

3 multi-keystroke strategies

- Multitap (similar to old handsets)
- Tree-based
- One-stroke (similar to T9)

Key-1: a, b, d, e

Key-2: f, g, h, i, j, k, l, m

Key-3: n, o, p, q, r

Key-4: s, t, u, v, w, x, y, z

Key-5: [space]

Key with desired character once.

Word appear after word completed- or resolve ambiguities

Results

Subject	measure	MultiTap	Tree-based	One-stroke
Subject 1	Median ikd	0.5	1.4	1.2
	Mean ch/min	22.5	13.0	28.5
	Median npvi	0.29	0.55	0.41
	Preverence	3/5	0/5	4/5
Subject 2	Median ikd	0.52	1.02	1.94
	Mean ch/min	27.2	18.6	31.1
	Median npvi	0.25	0.46	0.32
	Preverence	1/5	5/5	4/5
Subject 3	Median ikd	0.24	2.13	0.55
	Mean ch/min	26.5	7.7	26.2
	Median npvi	0.39	0.49	0.46
	Preverence	4/5	0/5	3/5

Results

Subject	measure	MultiTap	Tree-based	One-stroke
Subject 1	Median ikd	0.5	1.4	1.2
	Mean ch/min	22.5	13.0	28.5
	Median npvi	0.29	0.55	0.41
	Preverence	3/5	0/5	4/5
Subject 2	Median ikd	0.52	1.02	1.94
	Mean ch/min	27.2	18.6	31.1
	Median npvi	0.25	0.46	0.32
	Preverence	1/5	5/5	4/5
Subject 3	Median ikd	0.24	2.13	0.55
	Mean ch/min	26.5	7.7	26.2
	Median npvi	0.29	0.49	0.46
	Preverence	4/5	0/5	3/5

The tree based method is the slowest method, the least popular and the one with the largest npvi value

Results

The one-stroke method is the fastest to use and therefore preferred by subjects, but the high npvi value indicate cognitive difficulty

Subject	measure	MultiTap	Tree-based	One-stroke
Subject 1	Median ikd	0.5	1.4	1.2
	Mean ch/min	22.5	13.0	28.5
	Median npvi	0.29	0.55	0.41
	Preverence	3/5	0/5	4/5
Subject 2	Median ikd	0.52	1.02	1.94
	Mean ch/min	27.2	18.6	31.1
	Median npvi	0.25	0.46	0.32
	Preverence	1/5	5/5	4/5
Subject 3	Median ikd	0.24	2.13	0.55
	Mean ch/min	26.5	7.7	26.2
	Median npvi	0.39	0.49	0.46
	Preverence	4/5	0/5	3/5

Results

Subject	measure	MultiTap	Tree-based	One-stroke
Subject 1	Median ikd	0.5	1.4	1.2
	Mean ch/min	22.5	13.0	28.5
	Median npvi	0.29	0.55	0.41
	Preverence	3/5	0/5	4/5
Subject 2	Median ikd	0.52	1.02	1.94
	Mean ch/min	27.2	18.6	31.1
	Median npvi	0.35	0.46	0.32
	Preverence	1/5	5/5	4/5
Subject 3	Median ikd	0.24	2.13	0.55
	Mean ch/min	26.5	7.7	26.2
	Median npvi	0.32	0.49	0.45
	Preverence	4/5	0/5	3/5

The MultiTap method is easy to use and has the lowest npvi value indicating cognitive ease. But it is slower to use than one-stroke

Conclusions – median npvi

- Useful measure for comparing various text entry strategies
- Gives an indication of cognitive difficulty
- Can be applied directly to keystroke logs, independent of strategy
- No normalisation or scaling necessary
- Easy to compute
- Roboust to outliers
- Should not be used exclusively, but in conjunction with other quantities

Thank you!!!!

