Aviz

Visual Analytics Project

Motion-Pointing: Target Selection using Elliptical Motions

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There are situations when selecting an item by pointing is (very) difficult

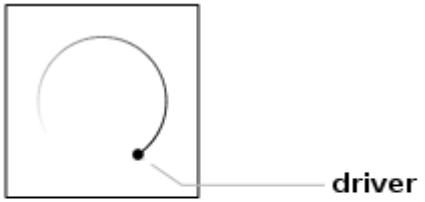

Cabas
en toile de riz
19€
été
thérapie


DEPART
DEPARTURE
ABFAHRT
Trains au départ
Departures trains
Abfahrt der züge
7°07 CREPY VILLERS SOISSONS ANIZY-PINON LAON
11°37 CREIL CLERMONT ST-JUST LONGUEAU AMIENS
12°43 ORRY-LA-VILLE CHANTILLY-GOUVIEUX CREIL
13°37 ORRY CHANTILLY CREIL CLERMONT ST-JUST
14°37 COMPIEGNE SAINT-QUENTIN AULNOYE MAUBEUGE
14°37 PERSAN CHAMBLY MERU ST-SULPICE BEAUVAIS
14°52 ARRAS LENS BETHUNE HAZEBROUCK DUNKERQUE
14°52 ARRAS DOUAI VALENCIENNES
14°54 PERSAN CHAMBLY MERU ST-SULPICE BEAUVAIS
14°55 BRUXELLES-MIDI
14°58 LILLE FLANDRES
15°01 DAMMARTIN CREPY SOISSONS ANIZY LAON
15°19 LONDON-WATERLOO
15°55 BRUXELLES LIEGE AACHEN KOLN
15°55 BRUXELLES BERCHEM ROTTERDAM AMSTERDAM
15°58 LILLE FLANDRES
16°07 CALAIS FRETHUN ASHFORD LONDON-WATERLOO
16°10 LONGUEAU AMIENS
16°16 CREIL PONT COMPIEGNE CHAUNY ST-QUENTIN
16°19 ORRY CHANTILLY CREIL CLERMONT ST-JUST
EN RAISON DU LANCEMENT DE NOTRE NOUVELLE OFFRE DE TARIFS ET DE SERVICES NOUS VOUS INFORMONS QUE LES VENTES SERONT SUSPENDUES AUX GUICHETS SUR LES AUTOMATES ET INTERNET LE SAMEDI 08-10-07 A 21H30
14:26


Départs - Departures

Solution:
Selecting by matching a motion

- For each target
  - Display an animated point called the *driver*
  - Drivers follow an elliptical trajectory
  - Each driver has a unique motion
- To select a button
  - Imitate its driver motion

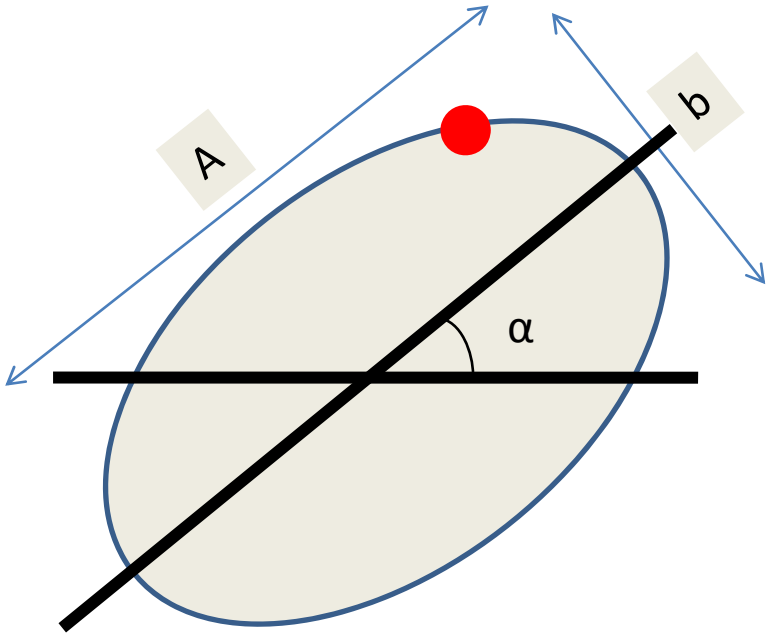


Rationale

- Why motion?
  - Motion is visible: no need to learn
  - No need to look at the pointer's cursor
    - Proprioceptive feedback is sufficient
- Why Elliptical?
  - Natural:
    - Periodical harmonic motion, minimizes the dissipation of mechanical energy, recycles potential energy into kinetic energy and vice versa
    - Ability of people to spontaneously couple themselves with an external oscillator
  - Stationary: can do it almost in place

Formal Setting

- Amplitude
  - A
- Aspect ratio
  - R=b/A
- Angle
  - A
- Period
  - P or Frequency = 1/P
- Direction
  - CW/CCW



Formative Study

- What are the human capabilities?

- F in {1, 4/3, 2, 4} Hz
- A in {5, 10, 20} pixels
- R in {0, 0.3, 0.6, 1}
- α in {0, 45, 90, 135} °
- D in {CW, CCW}

- 6 participants
  - 384 trials per session
  - 10s of recording,
  - approx. 1h20mn overall time
- 64Hz refresh rate
- Recorded:
  - Time
  - Driver X, Y
  - Pointer X, Y
- 640 samples per trial

Analysis

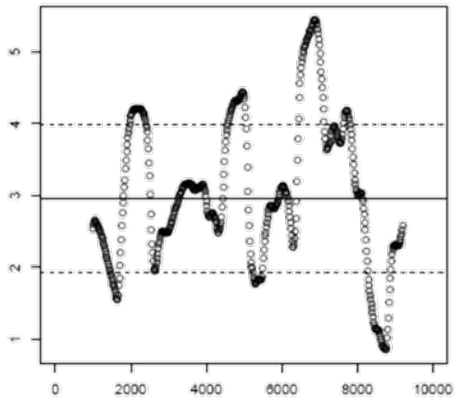
Spatial Analysis: Ellipse Fit

- On a 100 samples moving window
- Computes:
  - A, R, α (no F or D)
- StdDev of Fit
- StdDev of A, R, α

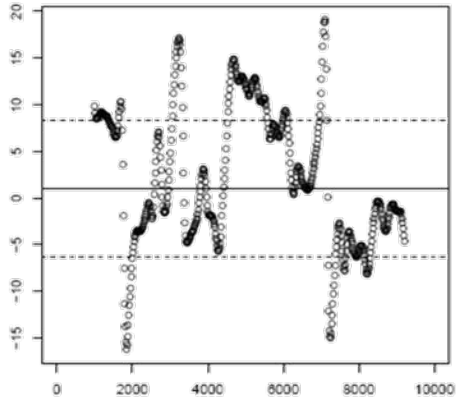
Temporal Analysis: Phase Error

- Phase of 1D signal:
  - +1 at each local max
  - -1 at each local min
  - Interpolated in between
- Phase Difference:
  - Phase(X)=Phase(Driver X) – Phase (Pointer X)
  - Phase(Y)=Phase(Driver Y) – Phase (Pointer Y)
- Phase Distance:
  - Dist(Phase(X),Phase(Y))

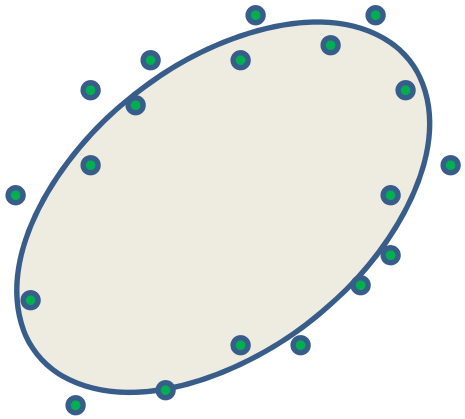
Spatial Analysis: Ellipse Fit

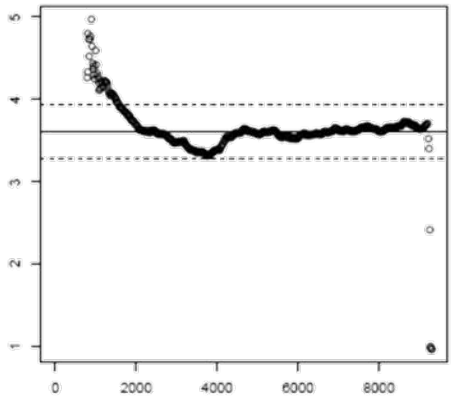


(a) Quality of fit

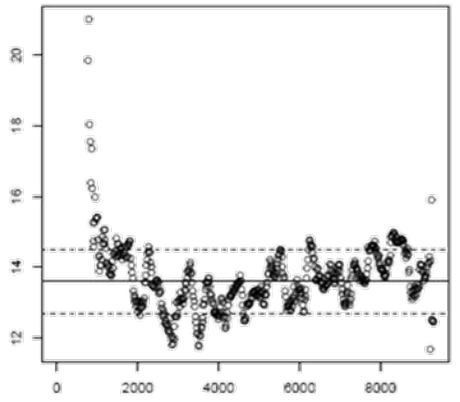


(b) Variation of angle



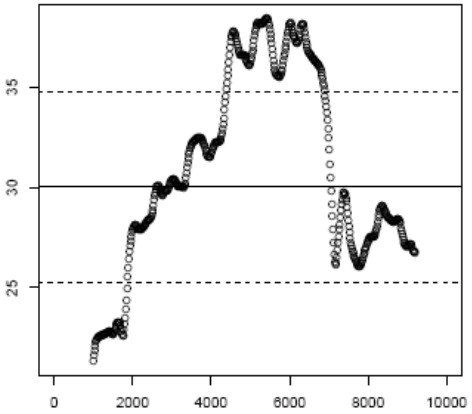


(e) Quality of fit averaged

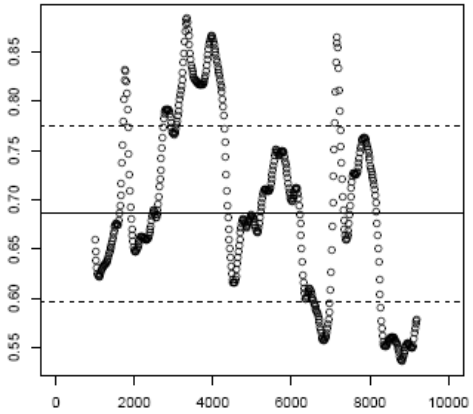


(f) Variation of angle av.

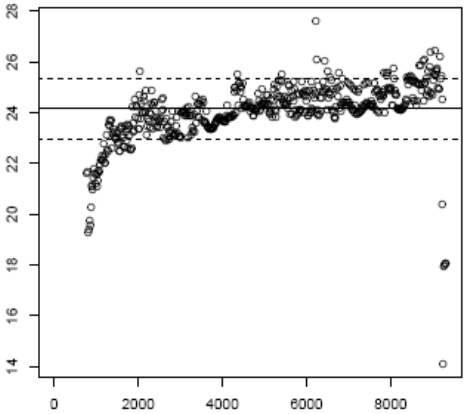
Spatial Analysis: Ellipse Fit (cont.)



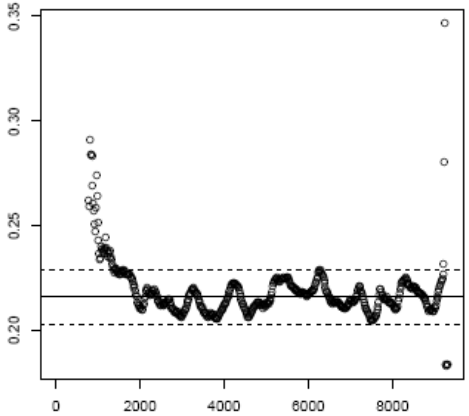
(c) Variation of amplitude



(d) Variation of ratio

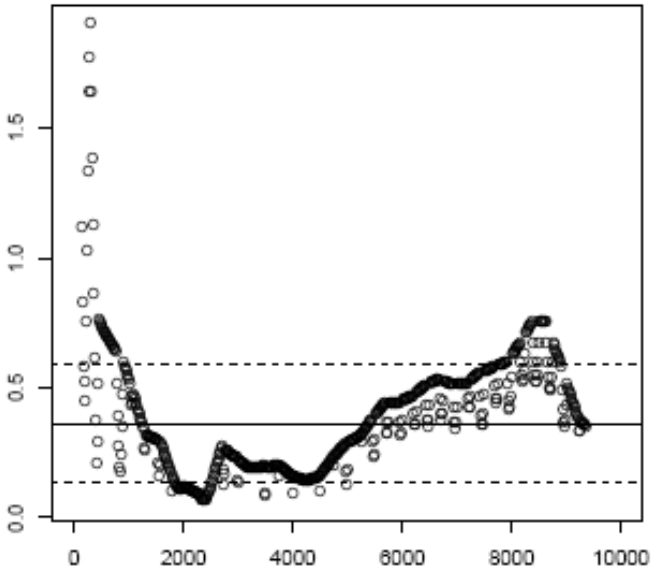


(g) Variation of amplitude av.

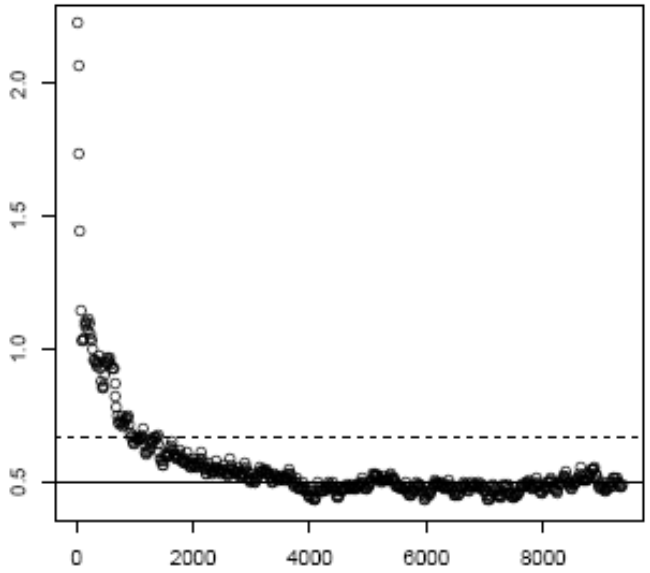


(h) Variation of ratio av.

Temporal Analysis: Phase Error



(a) Phase error for one trial.



(b) Average phase error.

How to Match?

- Use the relative movements (dx, dy)
- Euclidean Distance (ED)
  - $$f(u,d) = \sum_{i \in [t-w,t]} ((ux_i - dx_i)^2 + (uy_i - dy_i)^2)$$
- Normalized Euclidean Distance (NED)
  - $$f(u,d) = \sum_{i \in [t-w,t]} (\frac{ux_i}{||u_i||} - \frac{dx_i}{||d_i||})^2 + (\frac{uy_i}{||u_i||} - \frac{dy_i}{||d_u||})^2$$
- Correlation (C)

$$f(u,d) = \sum_{i \in [t-w,t]} ((ux_i \times dx_i) + (uy_i \times dy_i))$$

- NED on a 2s time window best

The Move&Stroke Technique

- Matching is not 100% accurate
  - 1) matching
  - 2) confirmation on 4best

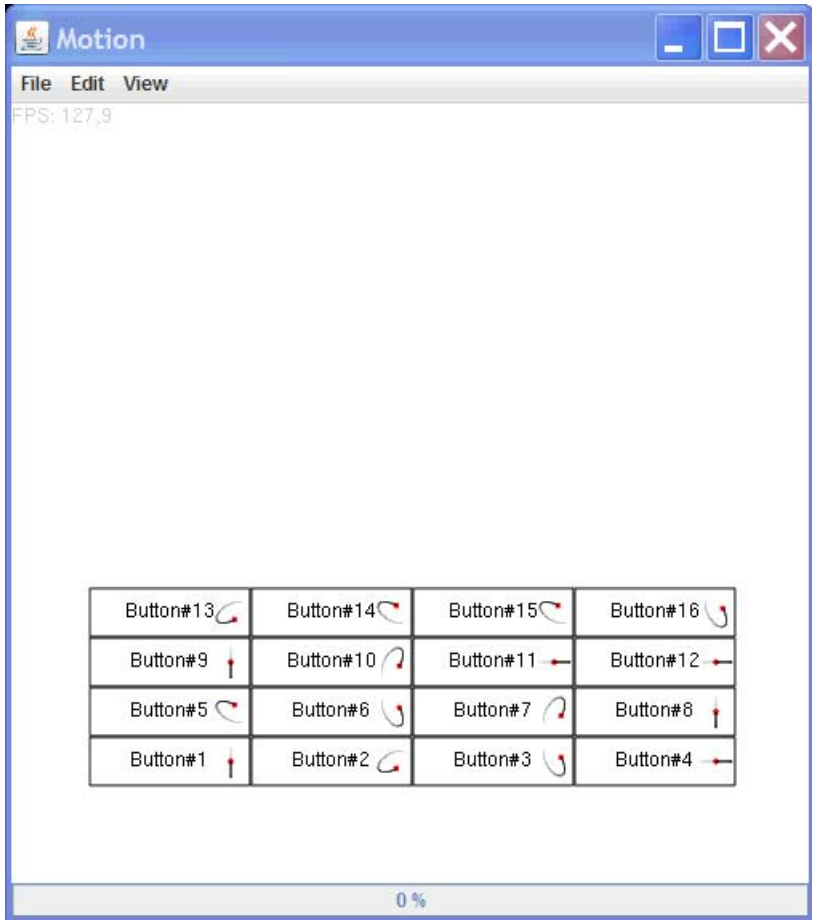
1) idle mode, wait for rotations

2) motion mode (no click)

3) Start stroke (stop motion)

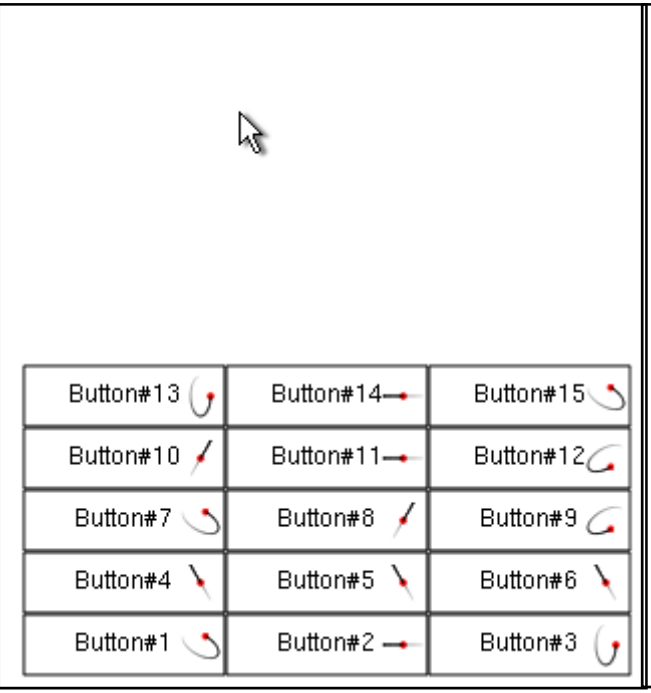
4) drag direction to confirm

5) Release stroke: selection

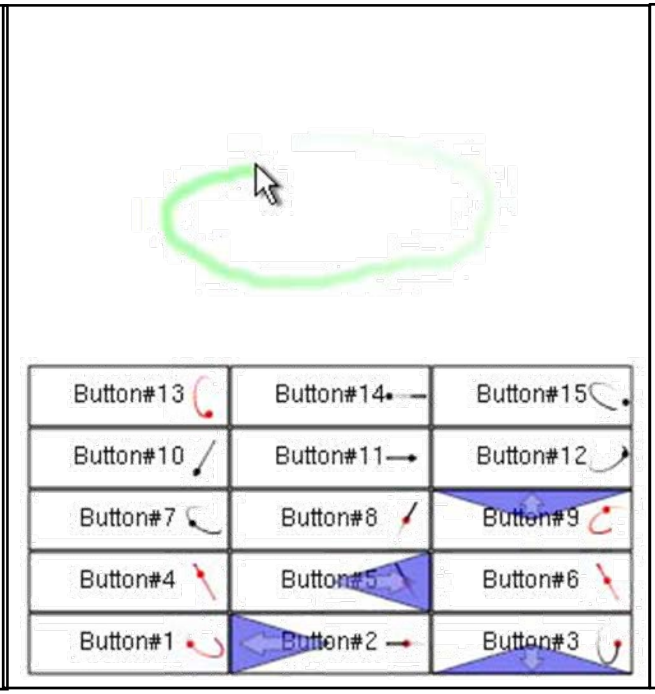


Move&Stroke

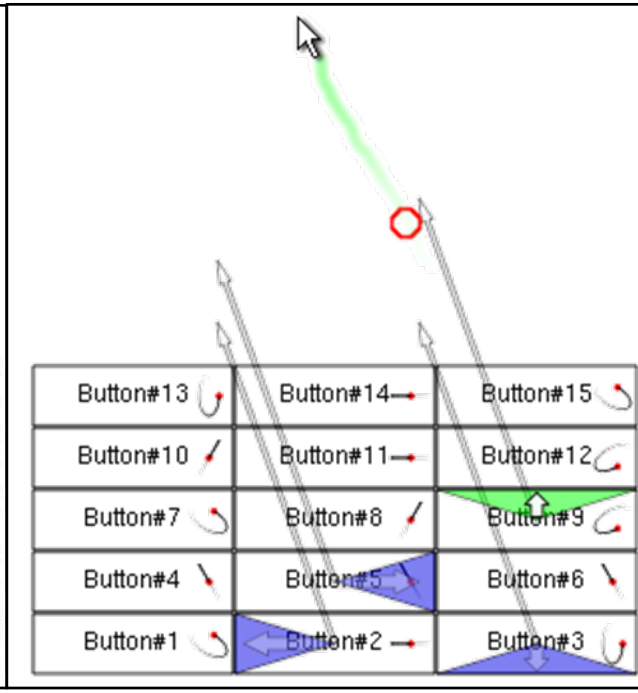
Idle



Move

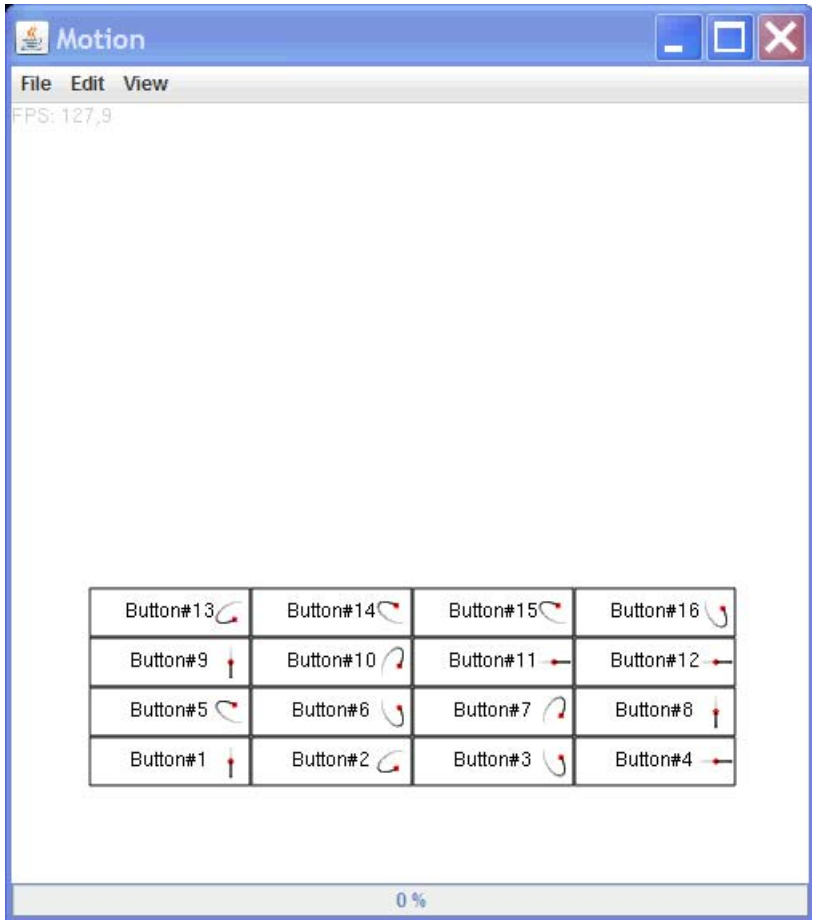


Stroke



Properties of Move&Stroke

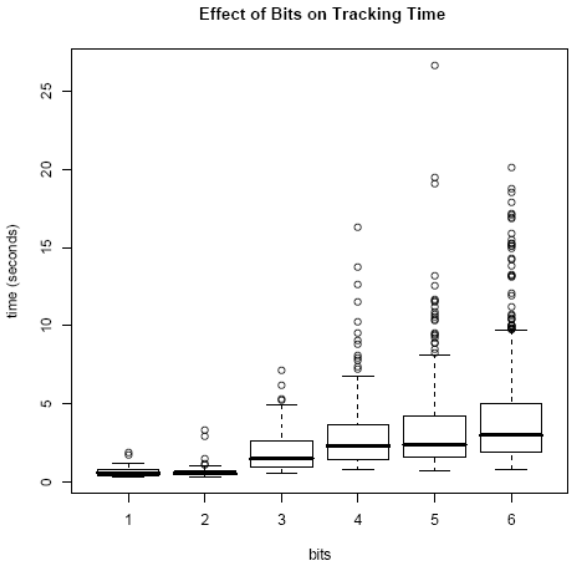
1. Fixed Gaze
2. Visibility and learnability
3. Robust to matcher errors
4. Simple and intuitive activation
5. Cancelation
6. Low visual clutter



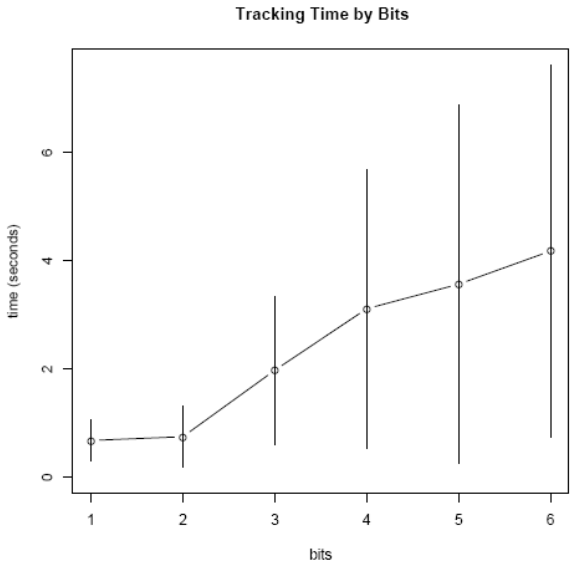
Summative User Study

- Interested in measuring the throughput
  - In bits per second
- With B bits, we can select 2^B buttons
- B in {1, 2, 3, 4, 5, 6}
  - 2, 4, 8, 16, 32, 64 buttons
- Times measured:
  - Idle->tracking (IT) no effect on B
  - Tracking->Selection (TS) significant effect on B
  - Selection->Idle (SI) no effect on B
- Ratio has a significant impact on TS performance
  - R=0 easier than R=0.5

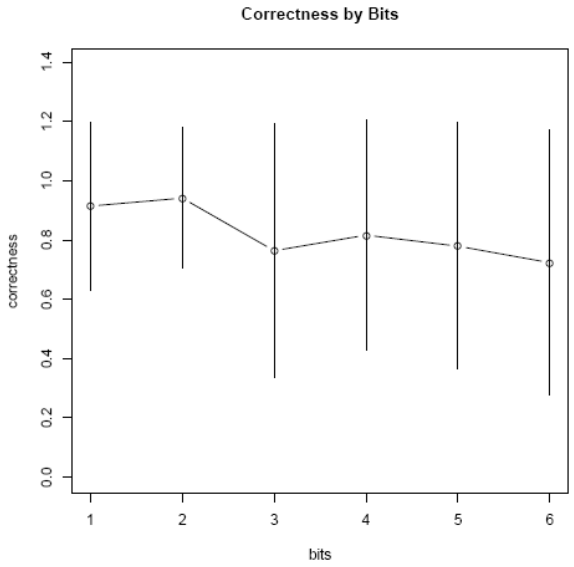
Results



(a) Tracking time (seconds).

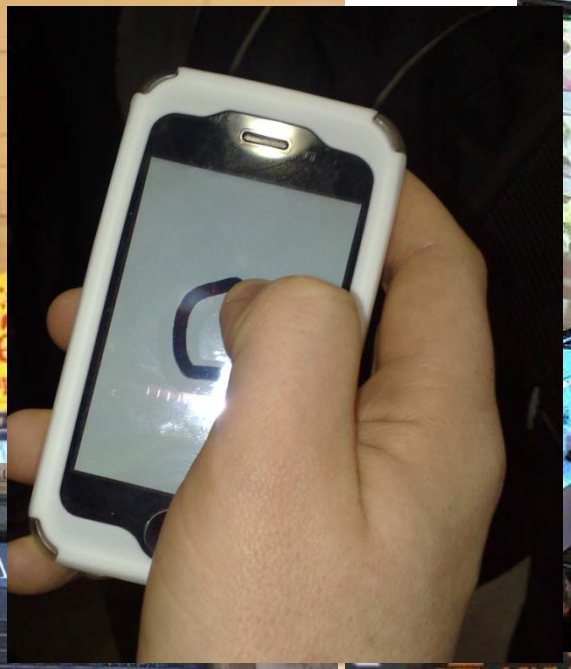


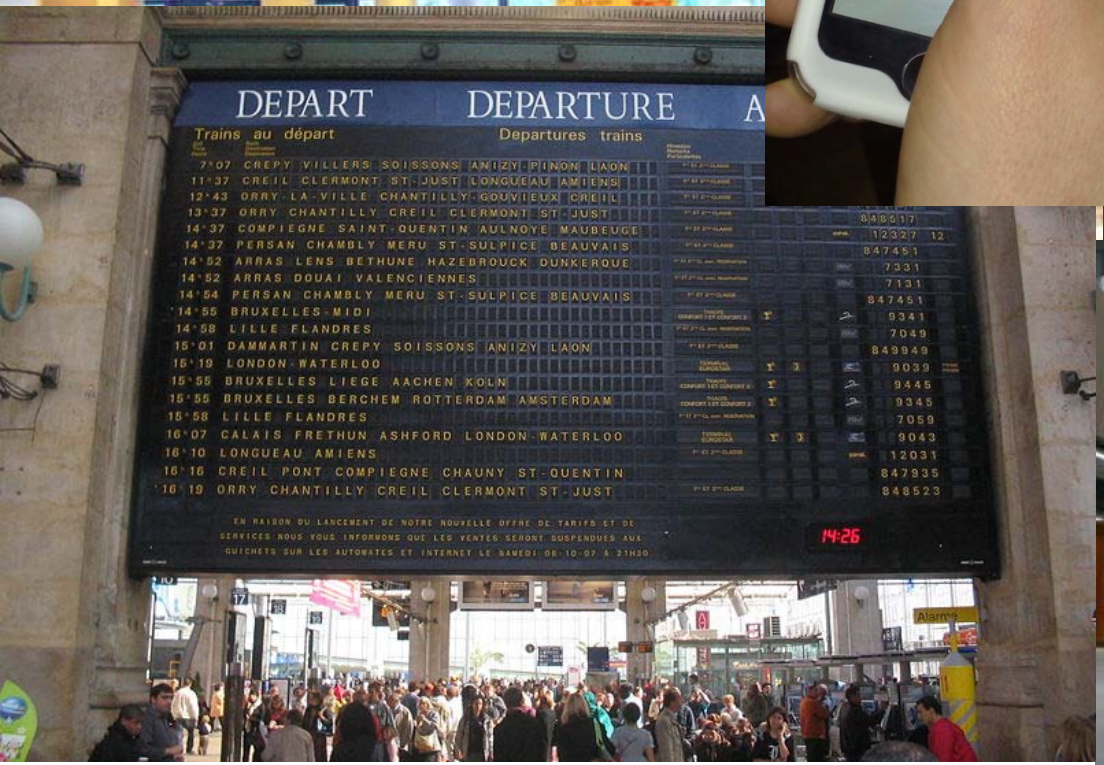
(b) Average tracking time (seconds).



(c) Average correctness (ratio).

Practical Use





Conclusion

- Humans are apt at reproducing oscillatory motions using a mouse/tablet/pad/finger
- Move&Stroke supports target acquisition with a time proportional to the number of bits
  - Practical technique for unreachable targets

- Improves with a bit of training
- Matcher should be improved
- Oscillatory motions are not produced only by the hand