Handwriting Stroke Kinematics

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Osborn on Measurement

Accurate measurements that can be proven to be accurate are of vital importance in connection with the investigation of certain phases of the subject of questioned documents.

QD, Ch. 6, (Instruments & Appliances), Pg. 92

Osborn on Measurement

…and to avoid possible error and to strengthen testimony it is desirable in all instances that measurements be made so that they can be reviewed and verified by judge, referee,or jury.

QD, Ch. 6, (Instruments & Appliances) Pg. 92

Osborn on Measurement

- No two genuine signatures can be exactly alike
- such a statement should be understood to be true speaking microscopically, and not as the carpenter measures
- genuine signatures of certain exceptional writers signatures can be found which are nearly identical.
(QD, Ch. 16, Pg. 281)

Osborn on Measurements

Actual measurements of the signatures themselves should always be made and opportunity and assistance should always be given for court and jury to verify all measurements.
(QD, Ch. 16. Pp. 288-9)
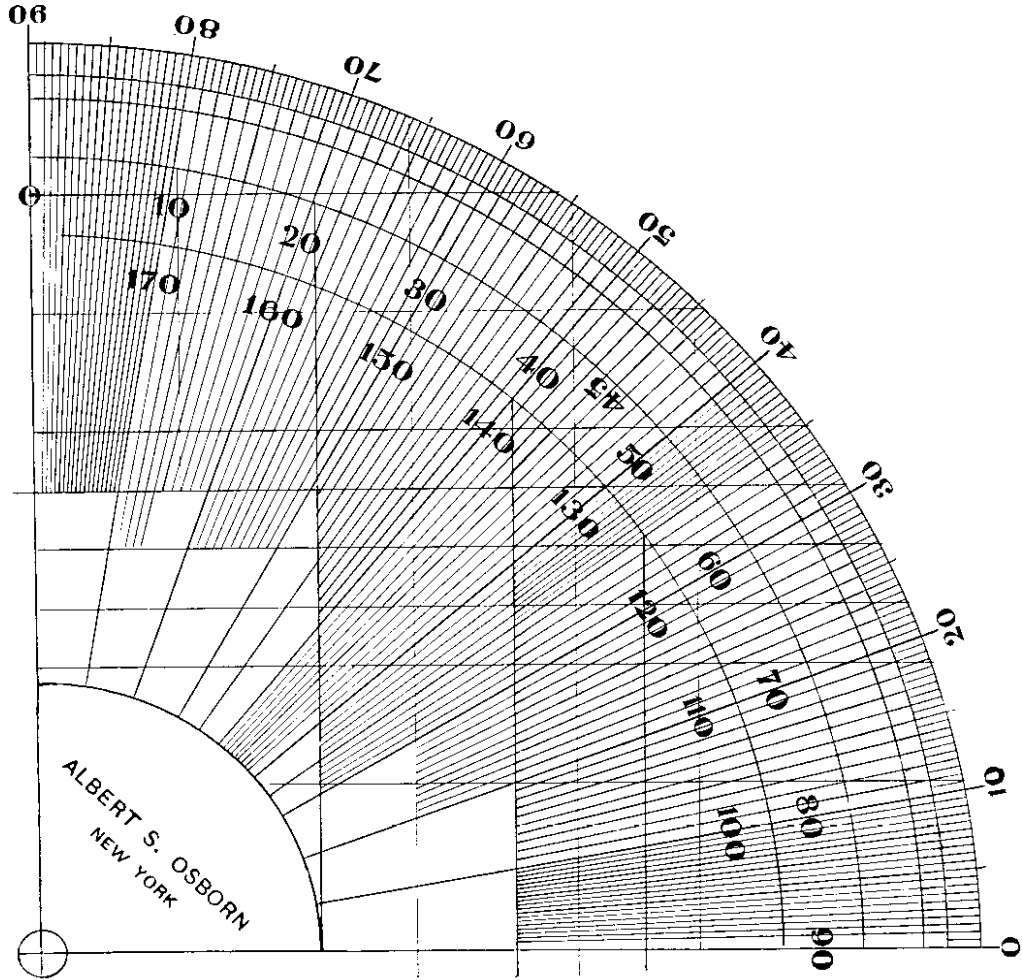
OSBORN PROTRACTOR

Handwriting Examination

Is Q = K?

Visual Comparison

- Side by side comparison
- Indicators of different authorship
- Indicators of disguise/simulation (forgery)
- Indicators of genuineness

NAS Report

- The scientific basis for handwriting comparisons needs to be strengthened (Pg. 166)

- Recent studies ...suggest that there may be a scientific basis for handwriting comparison, at least in the absence of intentional obfuscation or forgery.

  (Pp. 166-7)

NAS Report

- ...the committee agrees that there may be some value in handwriting analysis. (Pg. 167)

Possible Features for Measurement

- Complexity
- Strokes
  - Speed
  - Length (Size)
  - Curvature
  - Jerk (smoothness)
 - Pen Pressure
  - Spacing
  - Slant/Angles

Complexity Theory

– Complexity based on numbers of turning points and intersections

– Combination of spatial and fluency features that allows opinions to be expressed

– As complexity decreases the ease with which the spatial and line-quality features can be reproduced increases

  – Sita, Rogers, Found: Proceedings of the 11th Conference of the International Graphonomics Society, 2003.

Complexity

Complexity

Number of concatenated strokes
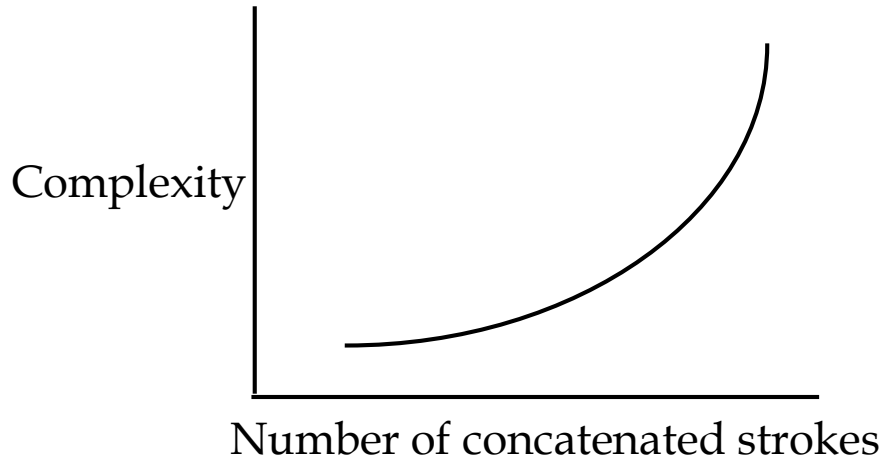
Likelihood of a chance match

Complexity

Ease of simulation
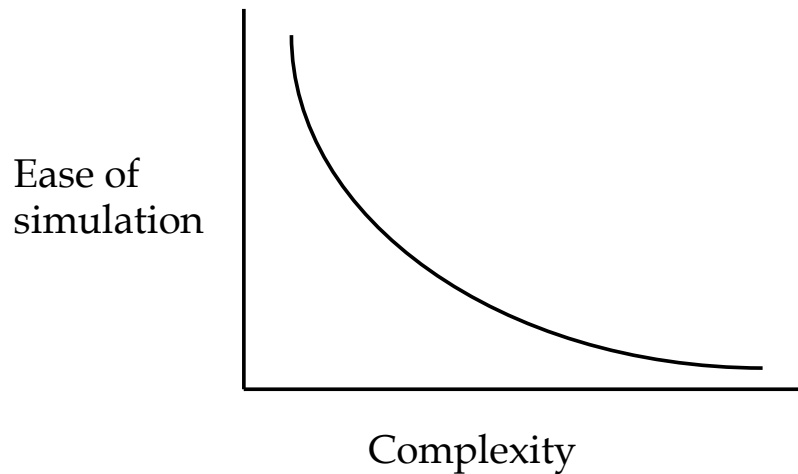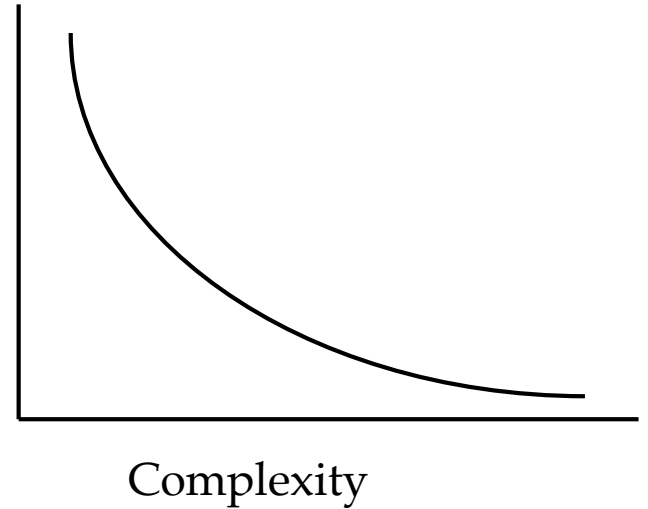
Complexity

Courtesy: Dr. Bryan Found

Complexity Theory

- FDEs performed best when identifying signatures of higher complexity
  - Sita, Found, & Rogers (2002)
- Strategies for human authentication may therefore benefit from a clearer understanding of the elements of complexity and, indeed, other features of a signature model which better reflect a justifiable confidence in judging authenticity

  - Fairhurst & Kaplani (IEEE, 2003)

Complexity Theory

- Complexity Scale
  - Alewijnse, Van Den Heuvel, Stoel, Franke (IGS 2009)

- $C = 11.72TP + 6.59L + 3.93INTRT - 1.93LGB - 4.44Int_{L\&LGB} + 54.95$

- C - Complexity; TP – Turning Points; INTRT – Intersections and Retraces; LGB – Legibility; L - Line length

- Represents the best estimation of complexity for the data set

Handwriting Comparison by Computer

- Srihari et. al. : CEDAR – FOX
  - Software to differentiate between genuine & forged signatures
- FLASH-ID: FBI, George-Mason U, Gannon
- Chen, Cha, Chee, Tappert (Rice U/IBM)
  - The Detection of Forged Handwriting Using a Fractal Number Estimate of Wrinkliness

Dynamics and Kinematics

Dynamics is concerned with the study of forces and torques and their effect on motion

Kinematics studies the motion of objects without reference to its causes.

Dynamics of Strokes

- A handwriting pattern is considered as a sequence of ballistic strokes and it is comprised of a series of upstrokes and downstrokes which may or may not be concatenated. (Teulings & Schomaker, 1993).

- Upstrokes and downstrokes influence the way handwriting is perceived.

- The slant of handwriting is judged by the downstrokes. (Maarse & Thomassen, 1983).

Dynamics of Strokes

- Downstrokes are found to be more invariant than upstrokes in terms of vertical size

- Downstrokes seem to be the information carriers of handwriting.
(Teulings & Schomaker, 1993).

Dynamics of Strokes

- Significant dynamic information (such as **velocity**) is lost to the examiner although estimates of these dynamics may be inferred (Ostrum & Tanaka, 2006; Guest, Fairhurst & Linnell, 2009).

- May be possible, using existing techniques, to measure **size** (Alkhatani & Platt, 2010) and **jerk** (Chen, Cha, Chee & Tappert, 2004; Huang & Yan, 2000).

Recent Studies

- Dynamics of Strokes
- Stroke Parameters
  - Duration
  - Velocity
  - Length (Size)
  - Jerk (smoothness)
  - Pen Pressure

Recent Studies

- Mohammed, L., Found, B. Caligiuri, M. & Rogers, D. (2011). *The dynamic character of disguise behaviour for text-based, mixed, and stylized signatures.* Journal of Forensic Sciences. 56 (S1):S136-S141.

- Caligiuri, M., Mohammed, L., Found, B. & Rogers, D. *Nonadherence to the isochrony principle in forged signatures*, Forensic Sci. Int. (2012), http://dx.doi.org/10.1016/j.forsciint.2012.09.008

Recent Studies

- Mohammed, L., Found, B. Caligiuri, M. & Rogers, D. *Dynamic Characteristics of Signatures: Effects of Writer Style on Genuine and Simulated Signatures* (JFS, in press)

- Other conference presentations and workshops

Equipment - Hardware

Facsimile check

John and Jane Doe
123 Main Street
Anytown, CA 12345 GEN

$

Equipment - Hardware
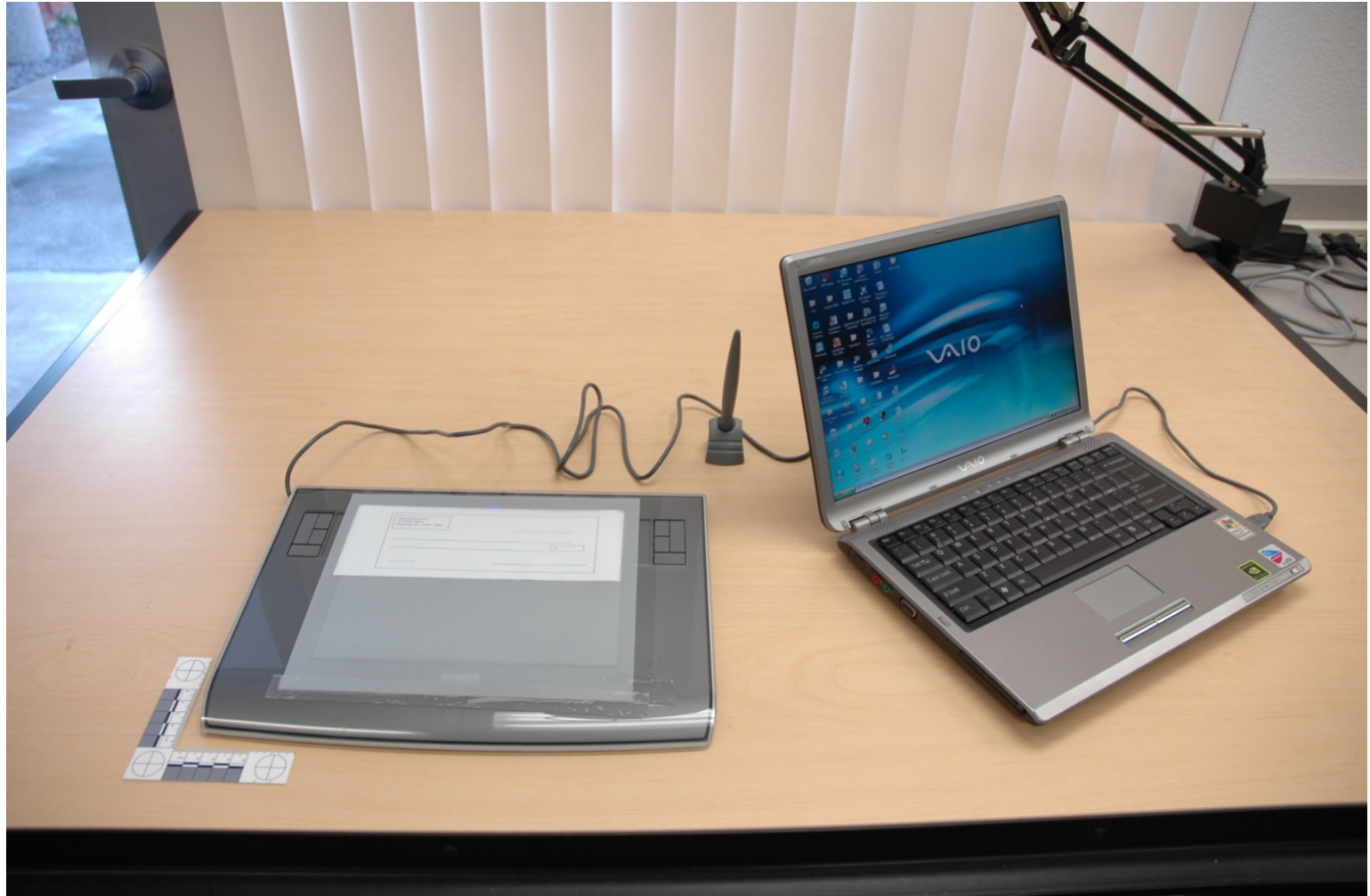
Wacom Intuos 3 Digitizer pad with inking pen

Wacom Inking Pen

Dynamics of Strokes

Equipment - Software

- Movalyzer software, V. 4.1 (Neuroscript Software, Inc.)

- Resolution: 5µ (accuracy: 0.01cm)

- Scanning: 200Hz

- Pressure levels: 1024
  - Based on manufacturer's specifications

Dynamics of Strokes

- Experimental Method
  - 60 writers (20 TB; 20 MX; 20 ST) signatures
    - 600 Genuine signatures
  - 60 writers simulate 3 signatures (1 TB, 1 MX, 1 ST)
  - Each subject simulates each model 15 times
    - 2700 simulations
    - Collected dynamically and in hard copy form
    - Wacom Intuos 3 Digitizer Tablet
    - Movalyzer software

Dynamics of Strokes
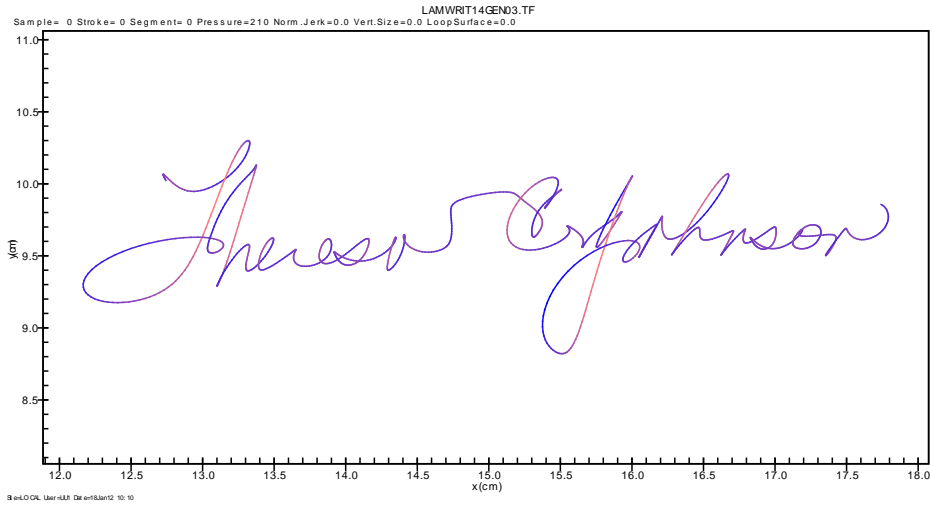
Genuine signature
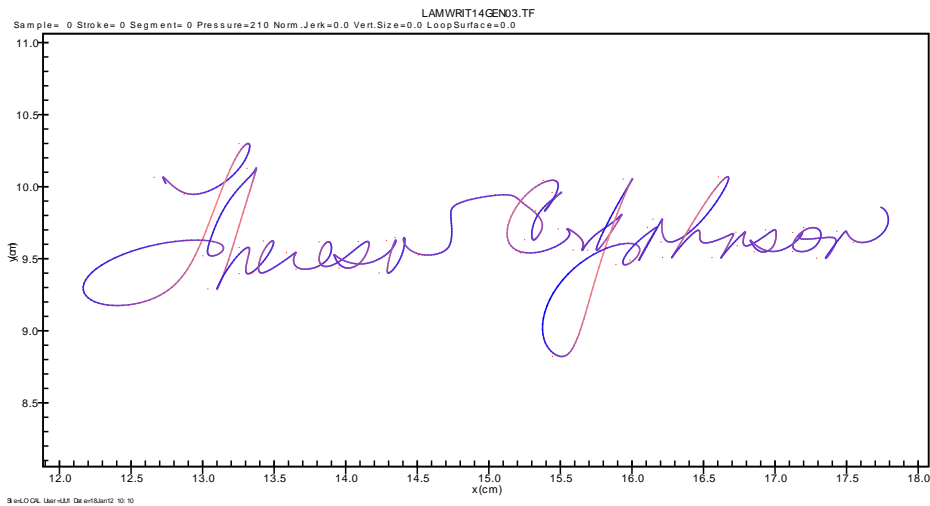
Genuine signature showing strokes

Movalyzer Images

LAM.WRIT14GEN01.TF

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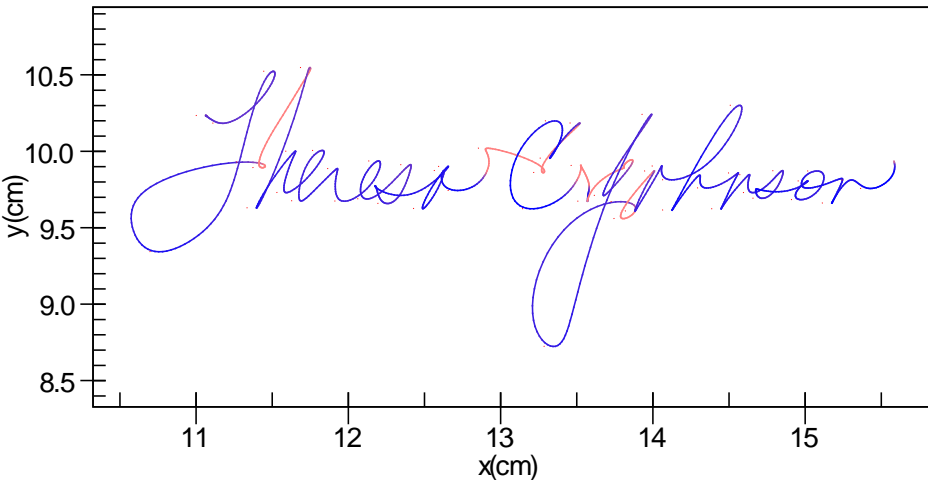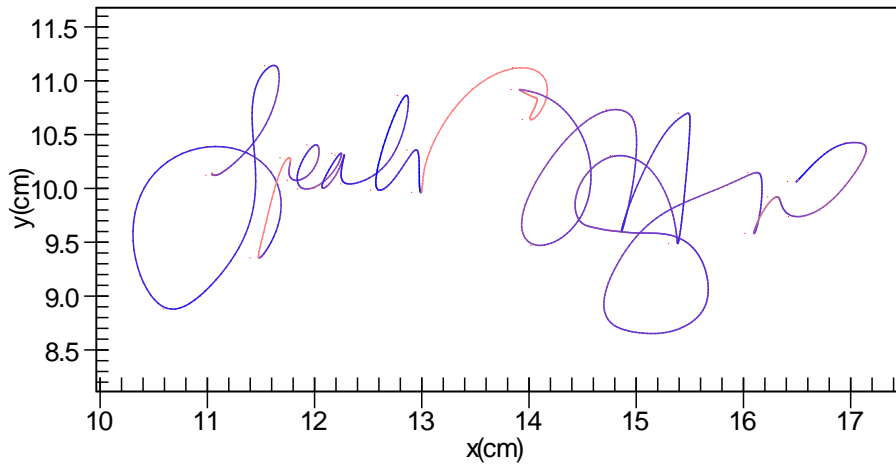

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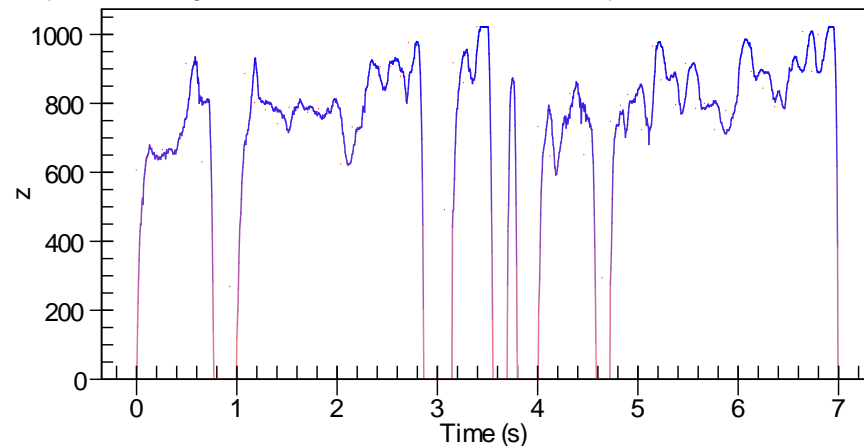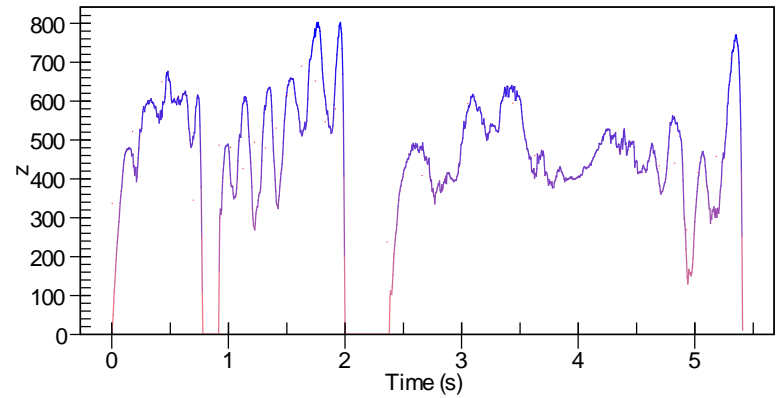

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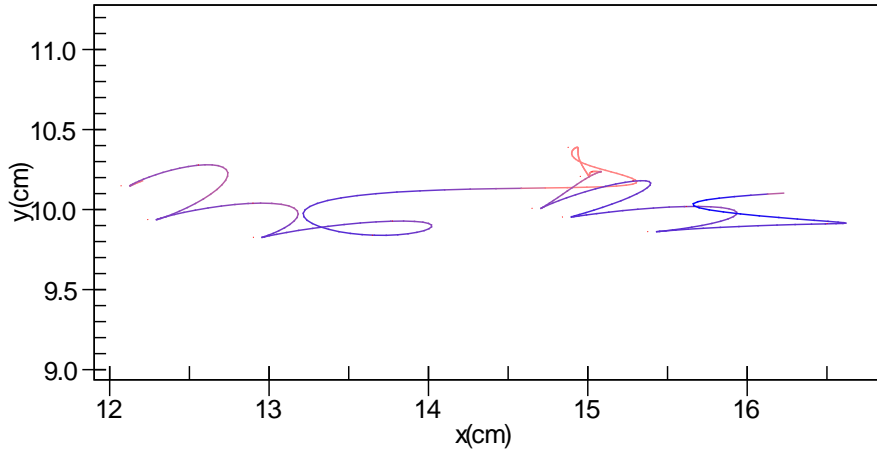Sample= 0 Stroke= 0 Segment= 0 Pressure=15 Norm.Jerk=0.0 Vert.Size=0.0 LoopSurface=0.0
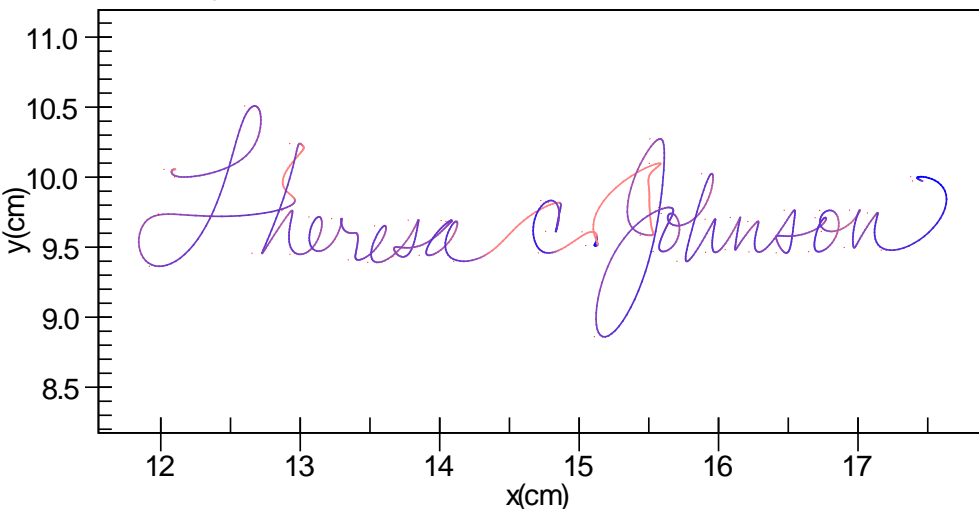
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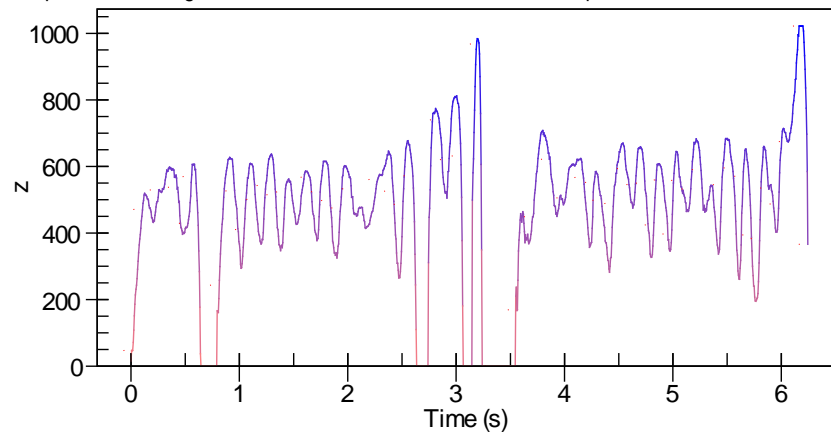
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Movalyzer Images
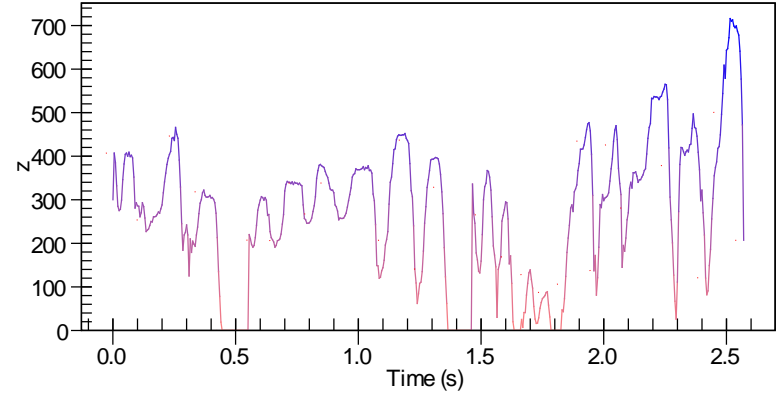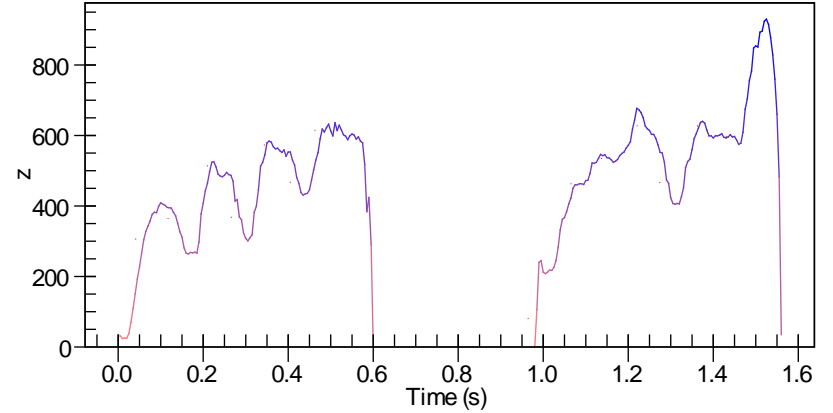
Movalyzer Images

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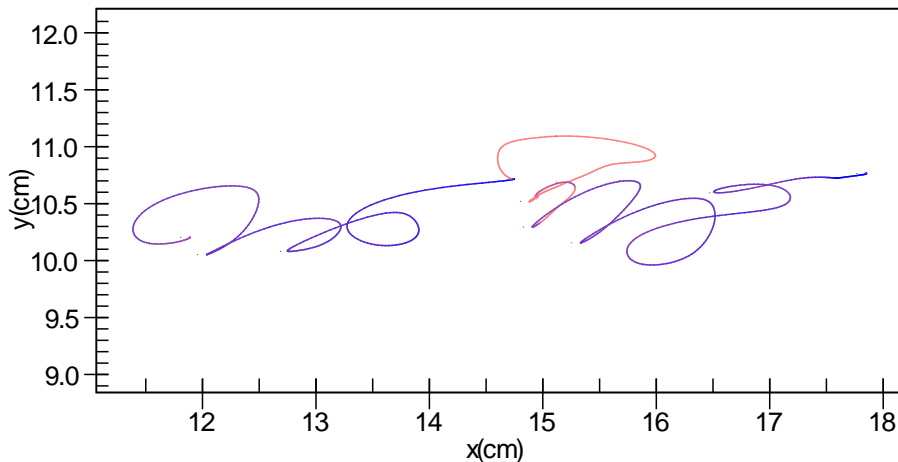Site=LOCAL User=UU1 Date=11Dec09 09:30

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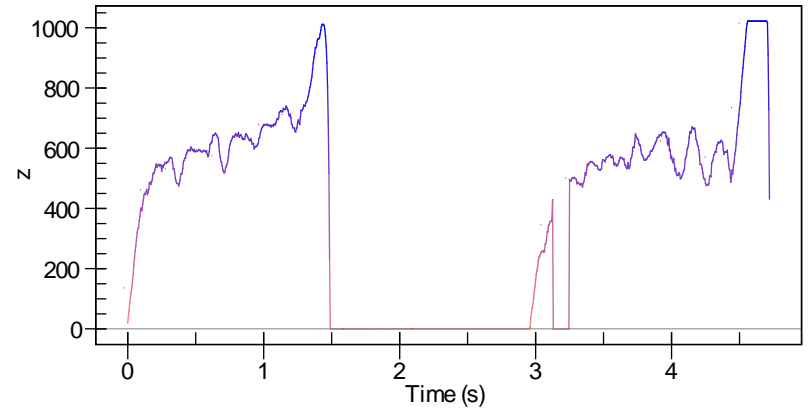Site=LOCAL User=UU1 Date=11Dec09 09:30

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Site=LOCAL User=UU1 Date=11Dec09 09:31

AAAFOR03FSTS01.TF
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Site=LOCAL User=UU1 Date=11Dec09 09:31

Databases Generated

- Two databases with Static and Dynamic Signatures

  1. 900 GEN, 450 DIS, 450 ASIM
     - 30 TBS, 30 MXS, 30 STS

  2. 600 GEN, 2700 SIM
     - 20 TBS, 20 MXS, 20 STS
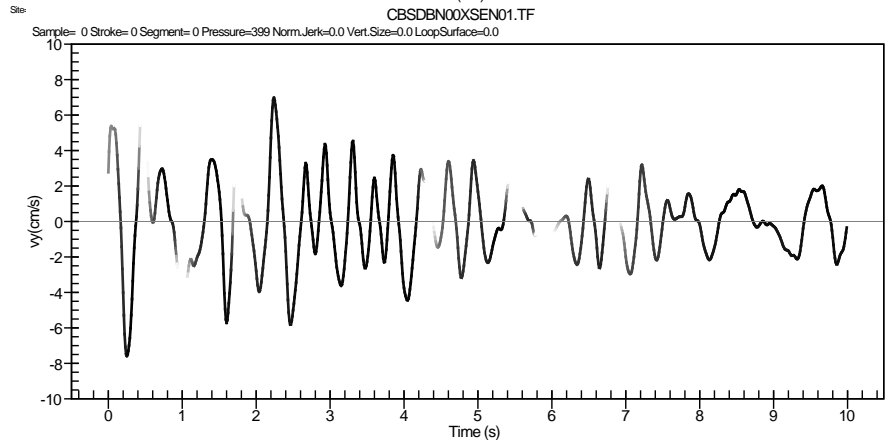
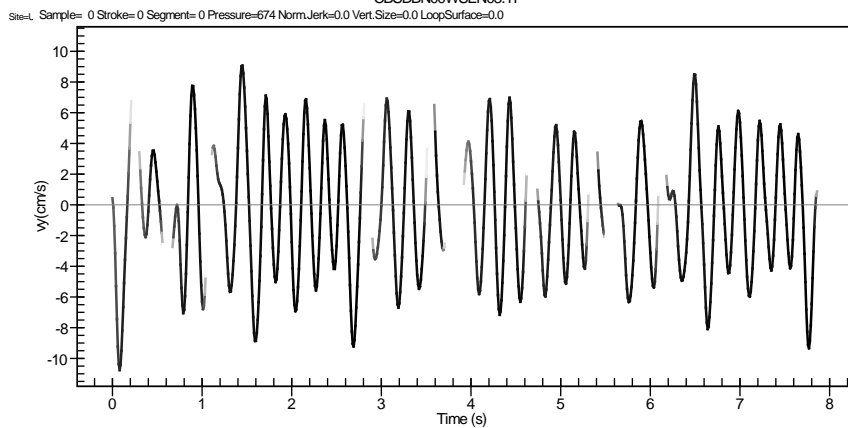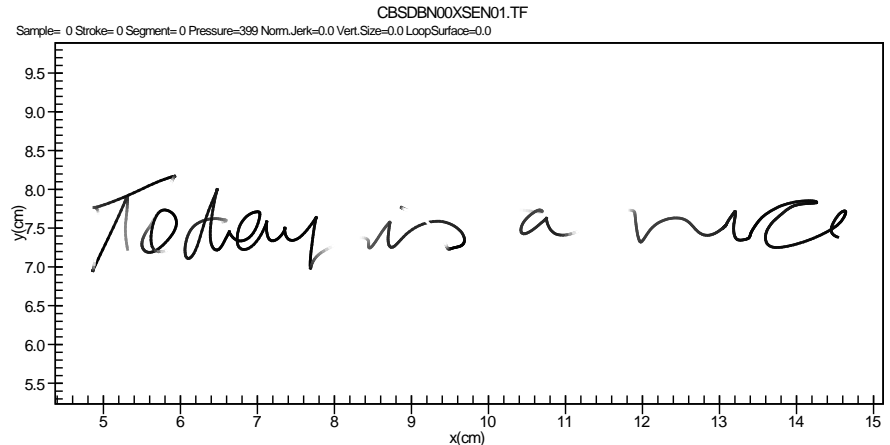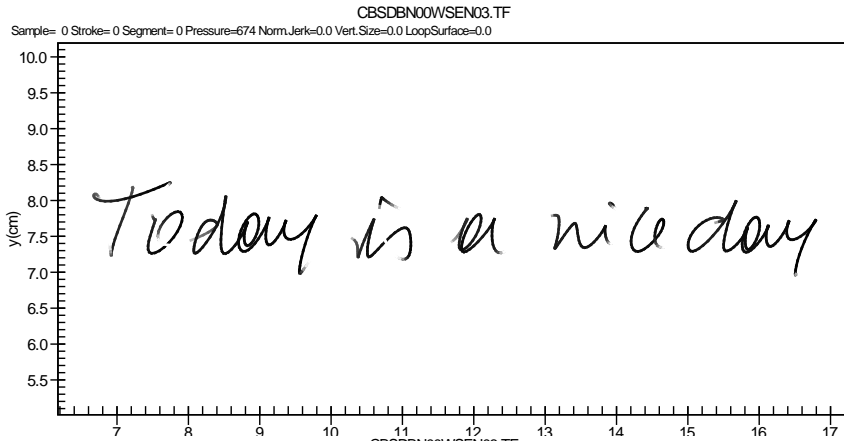# Use of Dynamic Information

- Compare dynamic data with published FDE material (genuine, disguised, simulated)
  - Stroke speed
  - Stroke size
  - Tremor
  - Blunt stops and starts
  - Upstrokes and downstrokes

Impaired Strokes

- Neuro-degenerative disease

- Illicit Drugs

- Medication

- Alcohol

- Aging

Cannabis:
Handwriting Kinematics

Courtesy: Prof. Michael Caligiuri, UCSD

Proposals for Future Study

- Research into dynamic movements (different handwriting behaviors)

- Generate dynamic databases

- Compare with static traces

- Impart information to FDEs in form of workshops and training

- Testing FDEs to see whether the training improves accuracy

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