$N-Protractor: A Fast and Accurate Multistroke Recognizer

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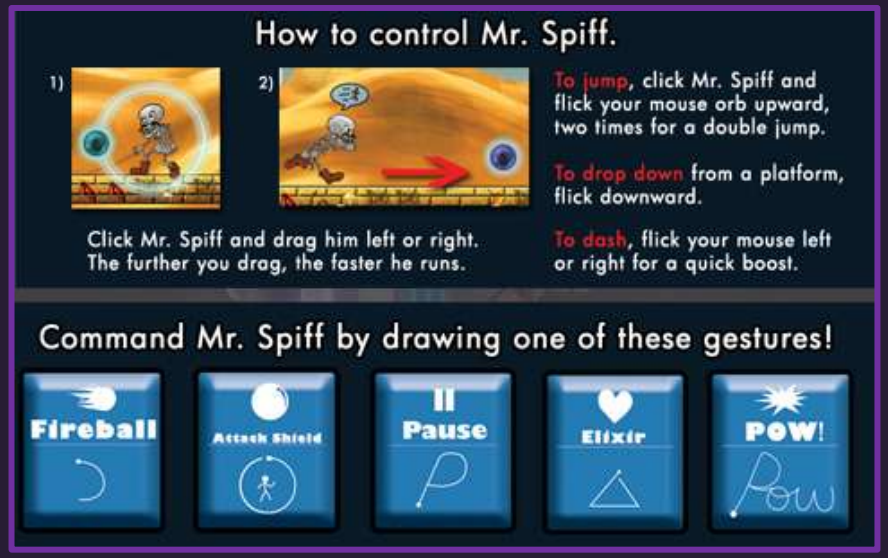
Graphics Interface 2012

Pen and Finger Gesture Input

My Word Coach (DS)

Obenkyo (Android)



Mr. Spiff's Revenge (PC)

Anthony & Wobbrock. $N-Protractor: A Fast and Accurate Multistroke Recognizer, GI 2012

Pen and Finger Gesture Input

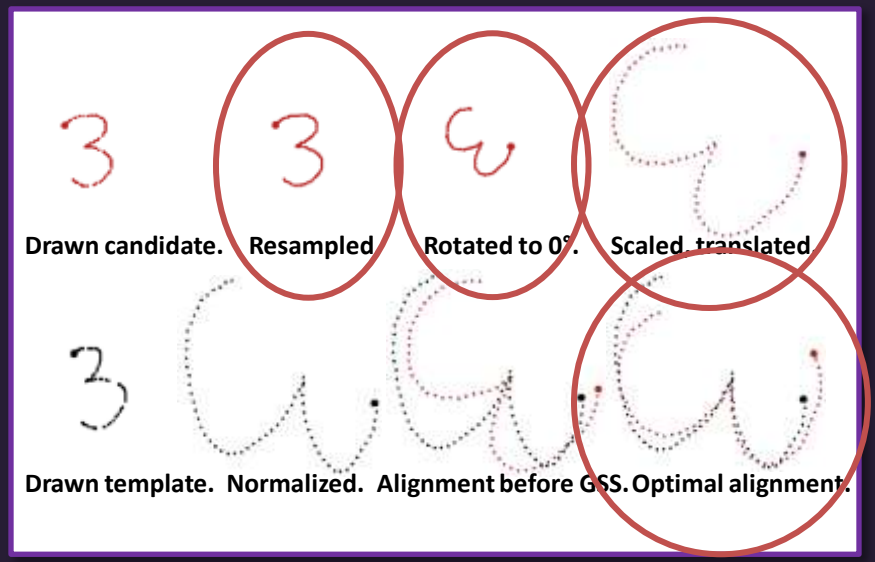
Gesture recognition for new platforms requires rapid prototyping but existing approaches are complex.

$1 is a simple, accurate recognizer to address this challenge for unistrokes.

- “one dollar” = cheap, fast, easy.
- [Wobbrock et al, UIST 2007]

$N Multistroke Gesture Recognizer

- $N extends $1 from unistroke to multistroke
  - Include pen-up periods
  - Recognize based on the entire path the arm takes in the air above the surface
- Template matcher: point per point correspondence (like $1)
- [Anthony & Wobbrock, GI 2010]



Pre-processing and matching for $N and $1

Open Source and Easy to Adapt

Open-source (C#, Java, more…)

- Rapid pick-up by community
- AlphaCount iPhone app
- iOS port of the recognizer

~100 lines of pseudo-code

Supports independent app development

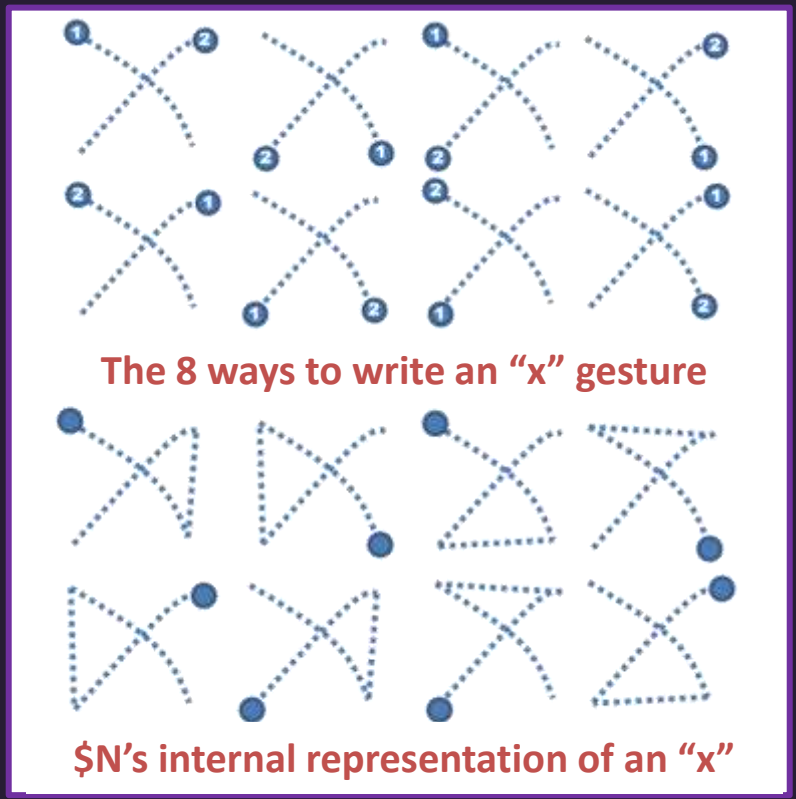
AlphaCount (iOS)

Space and Time Constraints

Space and Time Constraints

$N represents and tests all possible **permutations** of a given gesture (e.g., 8 ways to make an “x”)

- Easier for the user not to define them all
- Very costly in space and time for the system



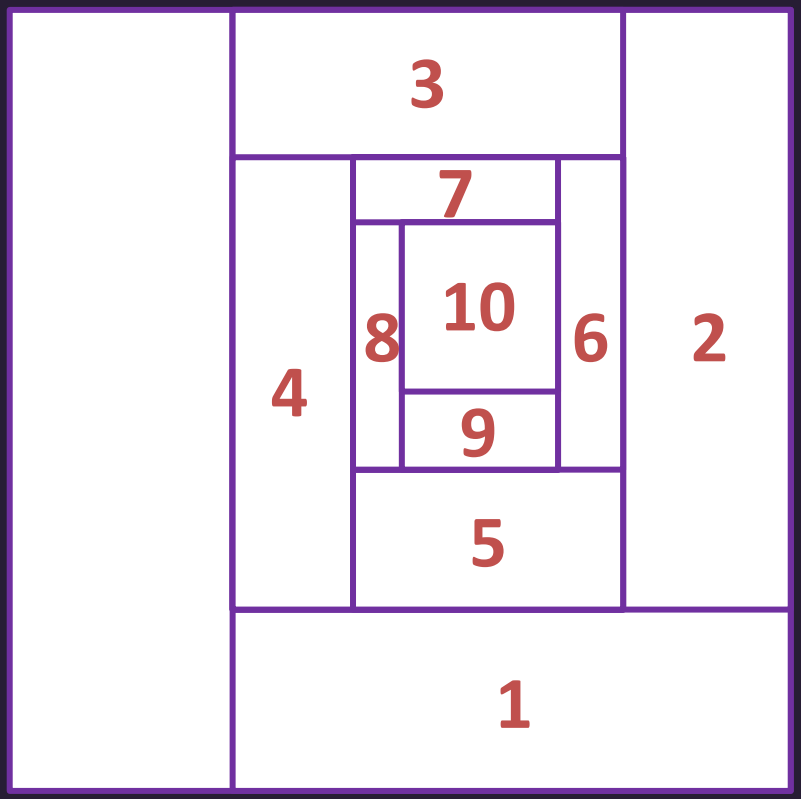
Multi-stroke representation of an “x”

Anthony & Wobbrock. $N-Protractor: A Fast and Accurate Multistroke Recognizer, GI 2012

Space and Time Constraints

$N uses **GSS** to find the best alignment between two gestures

- Rotation-invariant, tolerant to small variations
- All pairwise comparisons
- Iterative, time-consuming



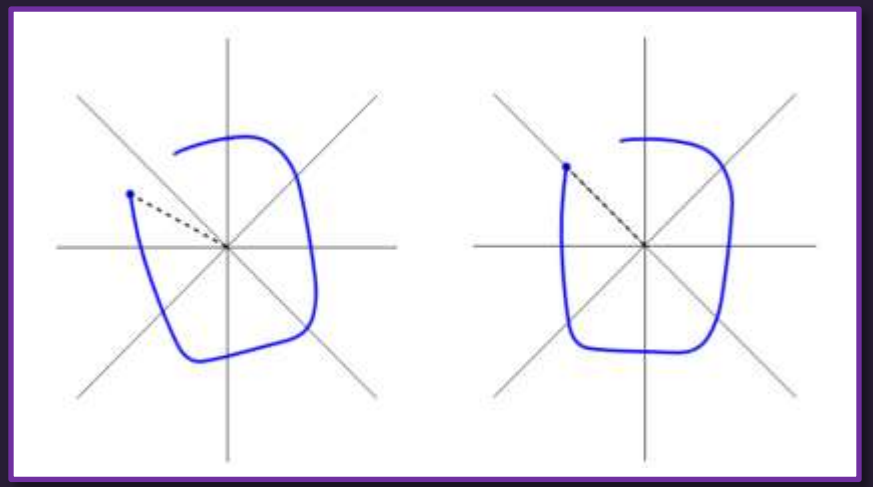
Approximation of Golden Section Search through a space

Anthony & Wobbrock. $N-Protractor: A Fast and Accurate Multistroke Recognizer, GI 2012

Optimal Alignment with Protractor

Protractor is a closed-form method to find best alignment for $1

- Approx. 80% time savings (for 16 gestures when 9 templates loaded)
- [Li, CHI 2010]
- http://yangl.org/protractor/protractor.pdf



Protractor's closed-form alignment [Li, CHI 2010]

Evaluating $N-Protractor

Added Protractor matching method to $N to replace GSS

- Protractor is essentially $1 with a different matching method

Cut out one source of time complexity in $N (iterative alignment search)

- Permutations cost remains

$N-GSS: $[(x_1, y_1), (x_2, y_2), (x_n, y_n)]$

$N-Protractor: $[x_1, y_1, x_2, y_2, \ldots x_n, y_n]$

Internal representations

Gesture Corpora Tested

Algebra Corpus

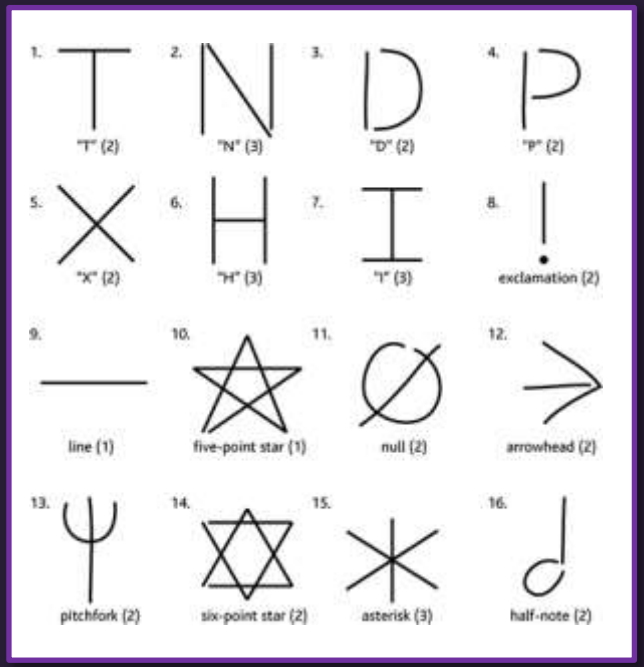
- 40 middle and high school students
- Unconstrained math symbols
- [Anthony et al, AIEd 2007]

$1 Unistroke Corpus

- 10 able-bodied adults
- Gesture and UI oriented symbols (1 stroke only)
- [Wobbrock et al, UIST 2007]

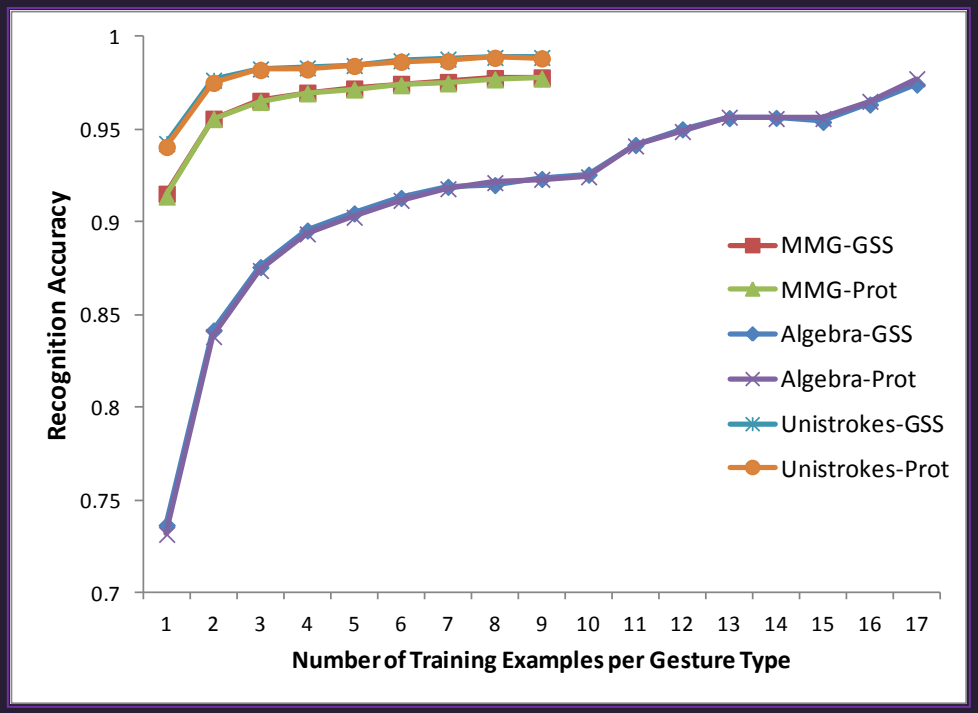
Mixed Multistroke Corpus

- 10 able-bodied adults
- Gesture and UI oriented symbols (1-3 strokes)



MMG Corpus

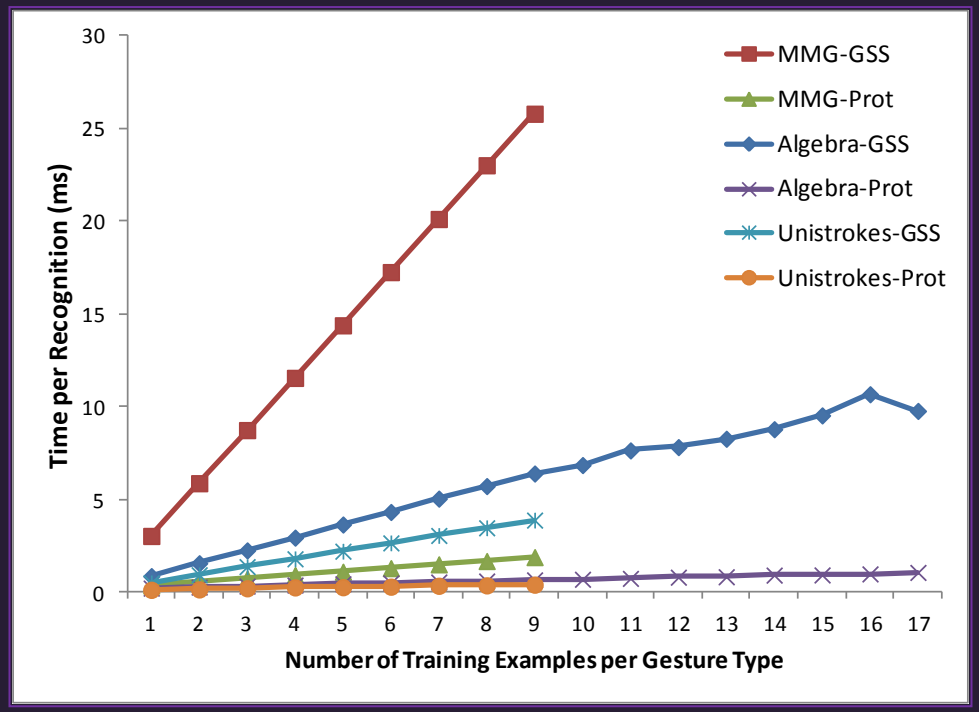
Recognition Accuracy



Recognition accuracy with Protractor vs. GSS for different corpora

- GSS and Protractor methods minimally different recognition accuracy
- Algebra dataset still most challenging for $N-family
- Unistrokes easiest

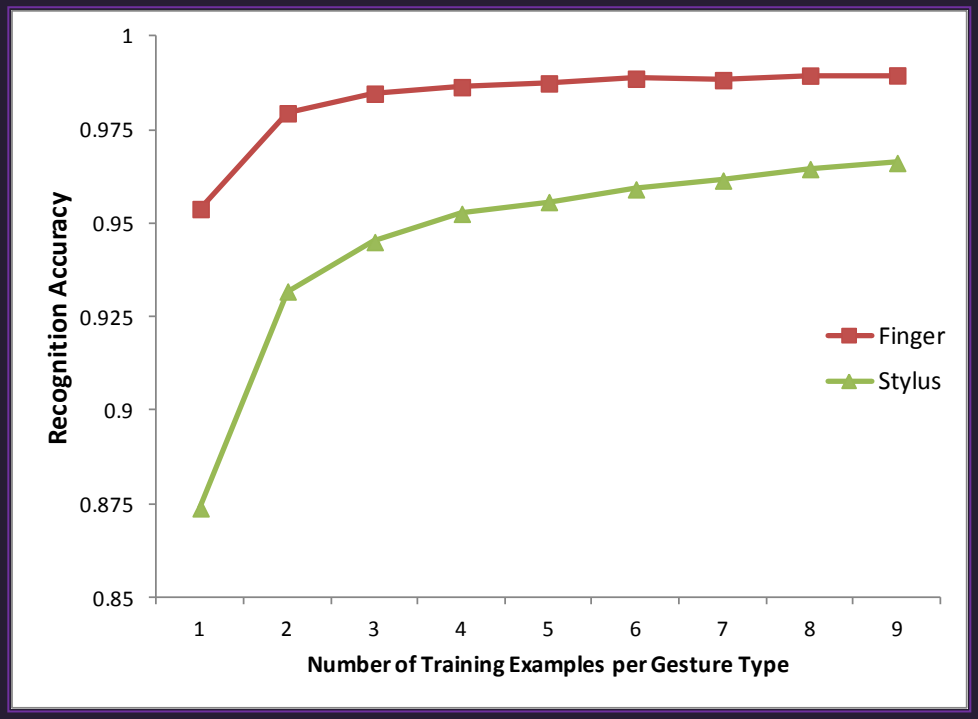
Recognition Speed



Time per recognition with Protractor vs. GSS for different corpora

- GSS consistently slower than Protractor on all datasets
- MMG: Protractor is more than 10x faster than GSS
- Benefits of Protractor magnified for multistrokes
- (More data was available for Algebra dataset)

Impact of Input Method and Speed



Accuracy w/ Finger vs Stylus Input

- Just for $N-Protractor
- Gestures entered via finger more accurate than stylus
- No difference due to input speed

Most Confusable Gestures

Tested gesture	Confused gesture	No. of confusions	% tests confused
Exclamation point	Half note	2488	4.6%
Line	[no result]	1466	2.7%
Exclamation point	N	1162	2.2%
H	N	822	1.5%
Six point star	Null	777	1.4%
Five point star	[no result]	749	1.4%
Exclamation point	Arrow	737	1.4%
Exclamation point	T	703	1.3%
P	D	608	1.1%
Half note	[no result]	561	1.0%
N	P	553	1.0%

Most confused gesture pairs in MMG corpus

- No symbol mis-recognized more than 4.6% of the time
- Worst recognized symbol was **exclamation point**
- Confusable pairs indicate small strokes and 1D gestures most difficult
- No reciprocal confusability relationships

Summary

- ✓ $N-Protractor highly **accurate**.
- ✓ $N-Protractor **>10x faster** than $N-GSS on MMG.
- ✓ $N-Protractor more accurate for **finger** than stylus gestures.
- ✓ No impact of **input speed**.
- ✓ $N-Protractor has trouble with gestures with very small component strokes (e.g., **exclamation points**) and thin gestures (e.g., **lines**).

Next Steps

Working on optimizations to reduce number of comparisons and permutations stored.

Coming soon: $P – a simple, fast and accurate point-cloud approach to gesture recognition!

Questions?

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Pseudo-code:

- http://depts.washington.edu/aimgroup/proj/dollar/ndollar.html

Anthony, L. and Wobbrock, J.O. 2012. $N-Protractor: A Fast and Accurate Multistroke Recognizer. Proceedings of Graphics Interface (GI'2012), Toronto, Canada.

References

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2. L. Anthony and J.O. Wobbrock. A lightweight multistroke recognizer for user interface prototypes. *Proceedings of Graphics Interface '10* (Ottawa, Canada, May 31-June 2, 2010), 245-252. Canadian Information Processing Society, 2010.

3. Y. Li. Protractor: a fast and accurate gesture recognizer. *Proceedings of ACM SIGCHI Conference on Human Factors in Computing Systems '10* (Atlanta, Georgia, April 10-15, 2010), 2169-2172. ACM Press, 2010.

4. J.O. Wobbrock, A.D. Wilson, and Y. Li. Gestures without libraries, toolkits or training: A $1 recognizer for user interface prototypes. *Proceedings of ACM Symposium on User Interface Software and Technology '07* (Newport, Rhode Island, October 7-10, 2007), 159-168. ACM Press, 2007.