Reconnaître un pattern de points de contact sur une surface tactile Multi-Touch et Machine Learning

Journée IHM-IA '17 Caroline Appert

IIDΛ

TouchTokens

R. Morales Gonzalez, C. Appert, G. Bailly and E. Pietriga. CHI '16. TouchTokens: Guiding Multi-Touch Patterns with Passive Tokens.



TouchTokens make it possible to easily build interfaces that combine gestures and tangibles



Data visualization



Tangible magic lens



Character controllers in a game



Access control

TouchTokens

Passive tokens indicating how to grasp them



Tactile surface



Touch pattern recognizer









Best alignment algorithm



Best alignment algorithm







permutations











Template

permutations







Template





permutations







Template





Results

Tablet: 99.3% *Tabletop: 98.7%* 100-100 T Recognition rate Recognition rate 75-75-50-50-25 25-0 0 5 5 5 5 5 4 5 5 '5

TouchTokens...

...are nice but the initial idea was even nicer!



Token without notches



Everyday objects

Let's see where we failed

Initial hypothesis



The shape of an object suggests a specific grasp, and thus a specific touch pattern. Objects that significantly differ in shape could thus be discriminated based on their touch pattern.

First study

Collection of touch patterns 12 "regular" tokens (no notches)

- Size = {3cm, 4cm, 5cm}
- Shape = {Square, Circle, Rectangle, Triangle}
- Size x Shape = 12 geometries





Could ML help?



TouchTools

Chris Harrison, Robert Xiao, Julia Schwarz, and Scott E. Hudson. CHI '14. TouchTools: leveraging familiarity and skill with physical tools to augment touch interaction.

<u>147 training instances</u> in total (7 participants x 7 tools x 3 repetitions) [...]

Our <u>features</u> are as follows: the number of touch points, the estimated total touch area, [...], angles between consecutively-clockwise points as measured from the centroid, and the size of each point. These features are then fed into a <u>support vector machine classifier</u> trained on previously recorded data.

Let's give it a try

scikit-learn? Weka?

	Weka E	xplorer			
Preprocess Classify Clust	er Associate Select attributes V	isualize			
Open file Open U	RL Open DB Gene	rate Undo	Edit		Save
Choose None					Apply
urrent relation		Selected attribute			
Relation: None Instances: None	Attributes: None Sum of weights: None	Name: None Missing: None	Distinct: None	Type: Unique:	None None
ttributes					
All None	Invert Pattern				
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Walcome to the Wake Further				Log	with Y
welcome to the weka Explor	er			Log	- CON ^

Weka explorer: a GUI! Nice!

Feed Weka explorer

What features? Let's try all the features we can think of

features.arff

@relation whatever

@attribute Participant numeric @attribute FingersCount numeric @attribute TouchArea numeric @attribute SmallestInscribedCircleRadius numeric @attribute MeanPairedDistance numeric @attribute MedianPairedDistance numeric @attribute MinPairedDistance numeric @attribute MaxPairedDistance numeric [...] @data 2, 4, -9850, 80.42, 120.68, 127.97, 46.69, 163.67, 43.31, 75.95, 69.7, 60.37, 104.03, 19.29, 81.17, 80.42, 80.42, 83.43, 1.5, 1.57, 1.67, 0.7, 2.24, 0.64, Square_5 2, 3, -1605, 36.8, 62.34, 64.4, 51.79, 70.84, 9.69, 36.02, 35.36, 30.99, 41.7, 5.39,

36.8, 36.8, 36.8, 36.8, 0, 2.09, 2.17, 1.79, 2.33, 0.28, Triangle 3

Explore with Weka Explorer

	Weka Explorer	
Preprocess Classify Cluster Associate Sel	ct attributes Visualize	
Classifier		
Classifier	ots 1 -K 0 -M 1.0 -V 0.001 -S 1 tput 0.620 0.038 0.598 0.620 0.609 0.781 0.024 0.744 0.781 0.762 0.552 0.037 0.577 0.552 0.565 0.528 0.044 0.521 0.528 0.525 Avg. 0.660 0.031 0.659 0.660 0.659 sion Matrix === c d e f g h i j k l < classifie 0 0 7 0 0 55 0 1 0 0 a = Square 42 14 7 0 4 0 0 0 12 8 b = Triang 192 38 3 0 15 0 2 0 19 8 c = Rectang 31 182 5 9 25 0 7 1 41 12 d = Triang 0 6 186 7 15 7 29 1 6 55 e = Rectang 0 4 4 247 3 1 6 53 6 0 f = Circle 14 18 13 4 202 0 36 1 5 28 g = Square 0 0 5 0 0 255 7 4 1 0 h = Circle 1 4 25 7 36 4 201 7 12 27 i = Triang 0 0 1 43 0 4 9 253 11 0 j = Square 24 28 9 7 9 1 17 19 179 19 k = Rectang 11 13 48 0 34 0 22 0 18 171 l = Circle	0.573 0.740 0.526 0.481 0.629 2d as 5 1e_3 1e_3 1e_4 1e_5 4 3 5 1e_5 4 3 5 1e_5 4 3 5 1e_5 4 3 5 1e_5 4 3 5 1e_5 4 3 5 1e_5 4 5 1e_5 4 5 1e_5 4 5 1e_5 4 5 1e_5 4 5 1e_5 4 5 1e_5 4 5 1e_5 5 1e_5 5 1e_5 5 1e_5 5 1e_5 5 1e_5 5 1e_5 5 1e_5
		
Status OK	Log	×0

So many concepts to understand...

Learn Machine Learning



It takes (way) too much time...

In the end...

Alternative approaches we considered led to significantly poorer performance. In particular, we tested k-Nearest-Neighbour (k=1 and k=3) and SVM algorithms, using both raw data and describing features. The raw data was pre-processed to make it independent from rotation angle and finger identification. The describing features we considered included the touch envelope's area, as well as various descriptive statistics (min, max, mean, median and standard deviation) for measures such as point-centroid distance, distance between successive points, distance between any pair of points, etc. These machine learning approaches yielded recognition rates ranging from 50% to 85% per participant.

> R. Morales Gonzalez, C. Appert, G. Bailly and E. Pietriga. CHI '16. TouchTokens: Guiding Multi-Touch Patterns with Passive Tokens.

Why?

Is ML not able to help?

Is the problem unsolvable?

Is the problem not captured in the right way (i.e., wrong describing features)?

Did we just fail to use it properly?

The design space for ML-based recognizers is very large: type of classifier, feature selection, size of training set, ...

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Is the problem unsolvable?

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What would be nice for designing MT recognizers

Collect empirical data

Compute describing features

Load it in a very simple GUI...

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:::: ToCHI Crédit Mutuel GScholar GMaps GTranslate Meteo	>> +
GUI4ML Input Form	
1. Upload Dataset File: Choose File	
2. Specify column names.	
Class column name: class	
Participant column name Participant	
3. (Optional) Maximum number of train session per class: 7 Submit	
Inia III SUNVERSITE	

...that <u>systematically explores</u> the design space of MLbased recognizers and tells me what the best solution is with <u>different training strategies</u> (global vs per-user)

Multi-touch recognizer and training



Pre-defined interfaces should ideally rely on a global training strategy

train with *n* users and test with the $(n+1)^{\text{th}}$ user



Customizable interfaces require a per-user training strategy

train with (x - y) examples from user nand test with the y remaining examples from user n

Multi-Touch & Machine Learning

Take-away message

We need easy-to-use tools that systematically explore the design space of ML-based recognition engines

Open question

Could ML help in designing incremental recognition engines for gestures with a continuous effect (e.g., pinch-to-zoom)?

Multi-Touch & Machine Learning

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