

The Semantics of Sketch: A Visual Query Systems For Time Series Data

Michael Correll

Michael Gleicher

The Semantics of Sketch: Flexibility In Visual Query Systems For Time Series Data



Michael Correll

Michael Gleicher

The Semantics of Sketch: Flexibility In Visual Query Systems For Time Series Data



Michael Correll
Michael Gleicher

Argument

Sketch can be useful for querying

Argument

Sketch can be useful for querying

BUT

We have to handle “invariants”

Argument

Sketch can be useful for querying

BUT

We have to handle “invariants”

What's the weather like?



What's the weather like?



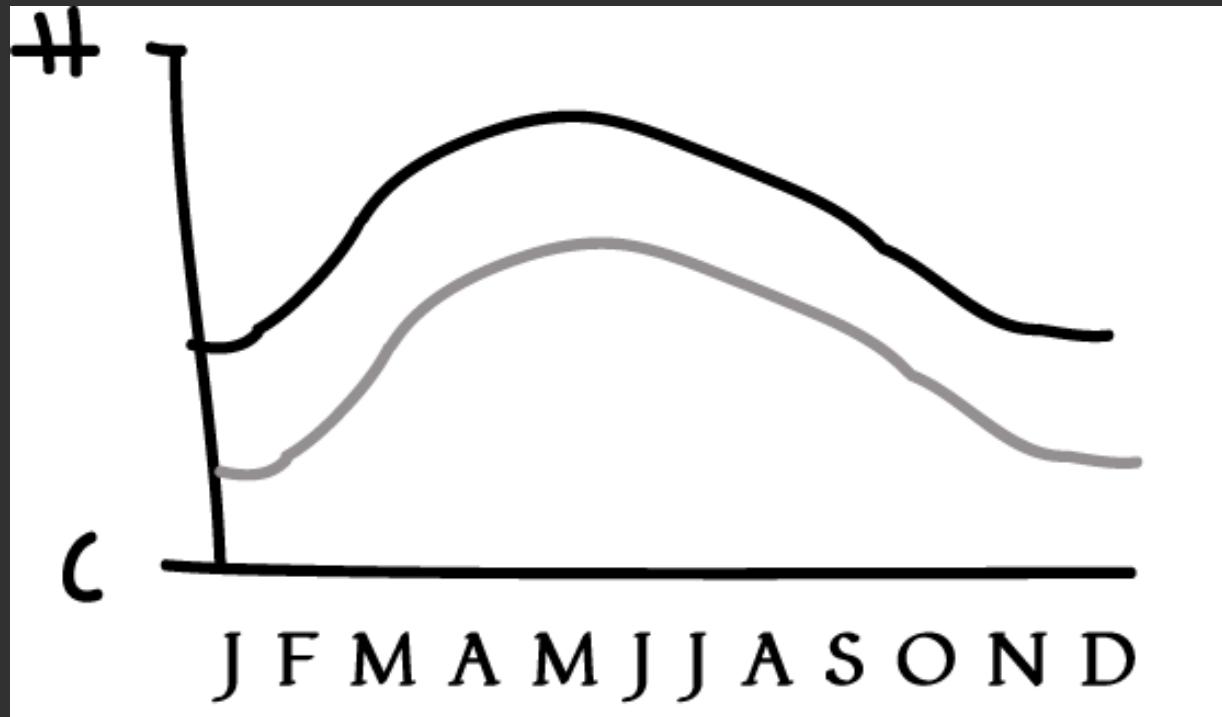
What's the weather like?



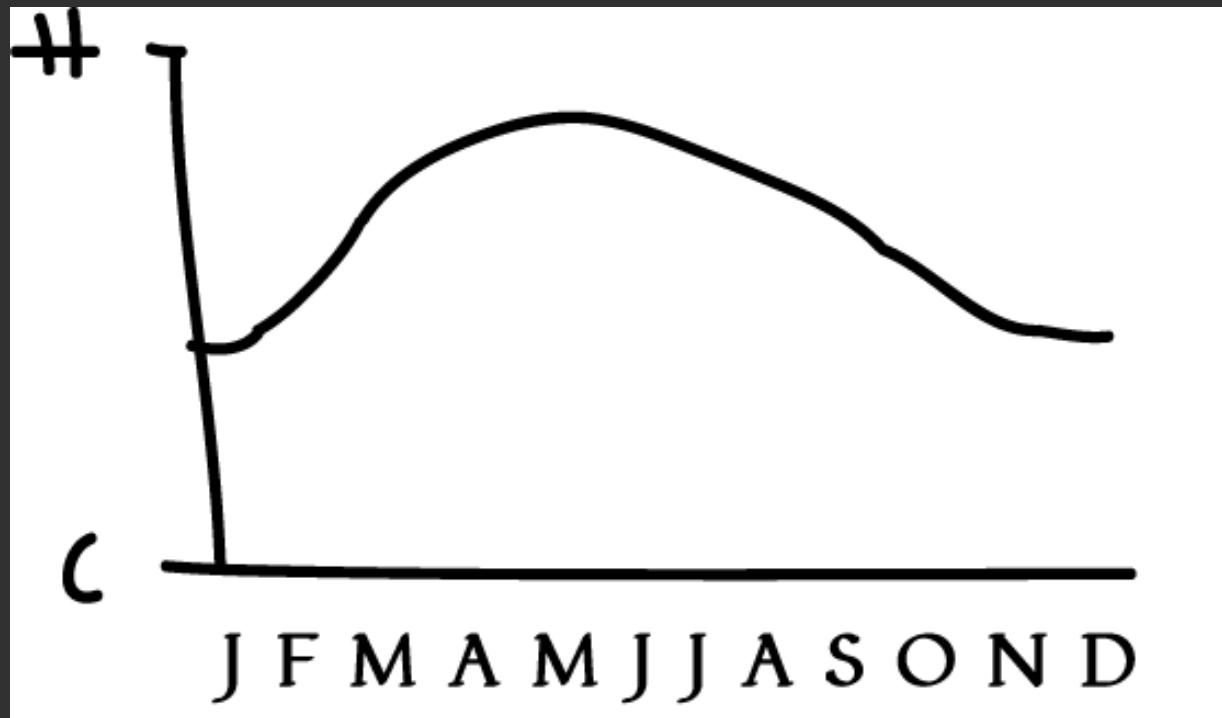
What's the weather like?



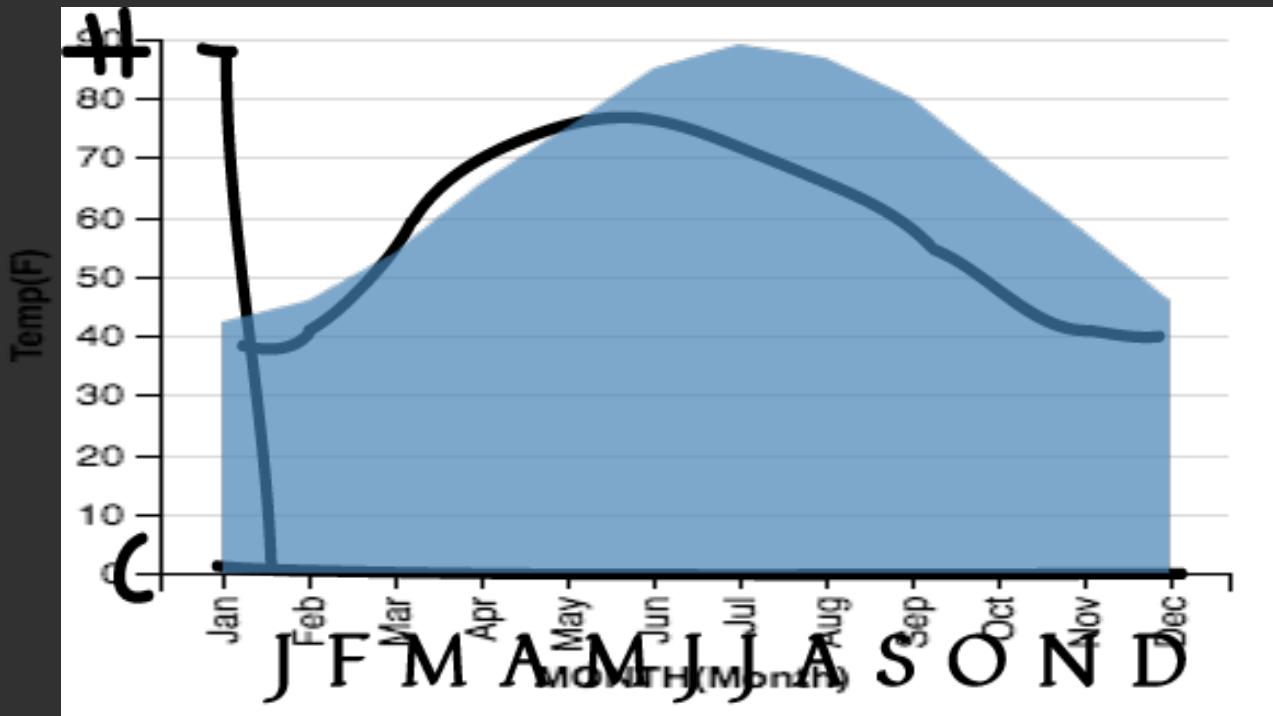
What's the weather like?



What's the weather like?

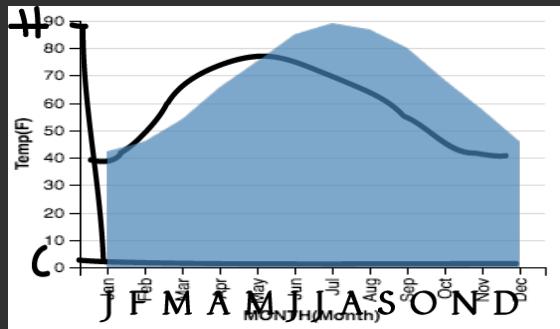


Sketching is expressive

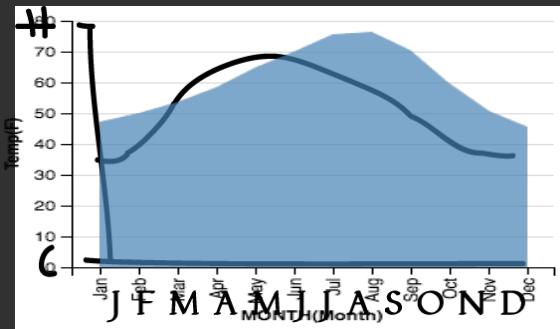


Sketch as Query

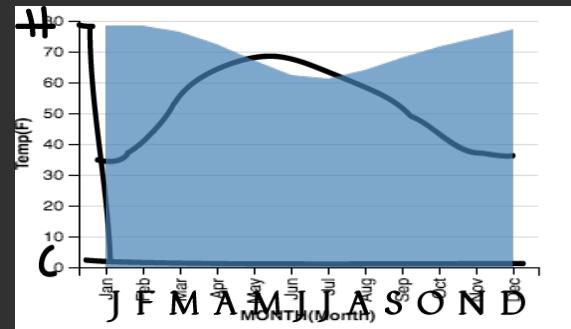
Baltimore



Seattle

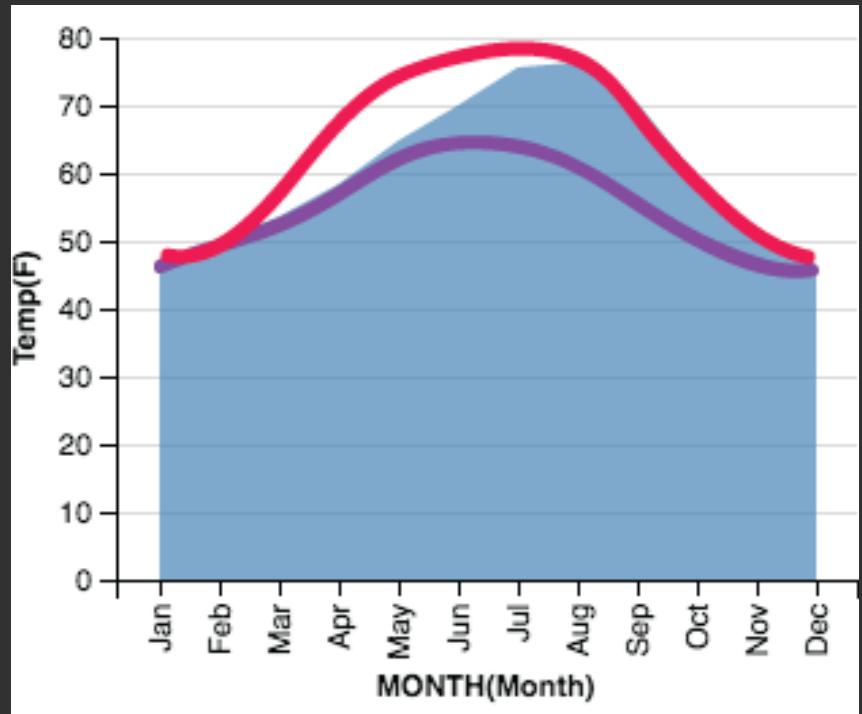


Sydney



Query Language=Results Language

Are there cities with:
Longer summers?
Colder summers?



Sketching is natural

People

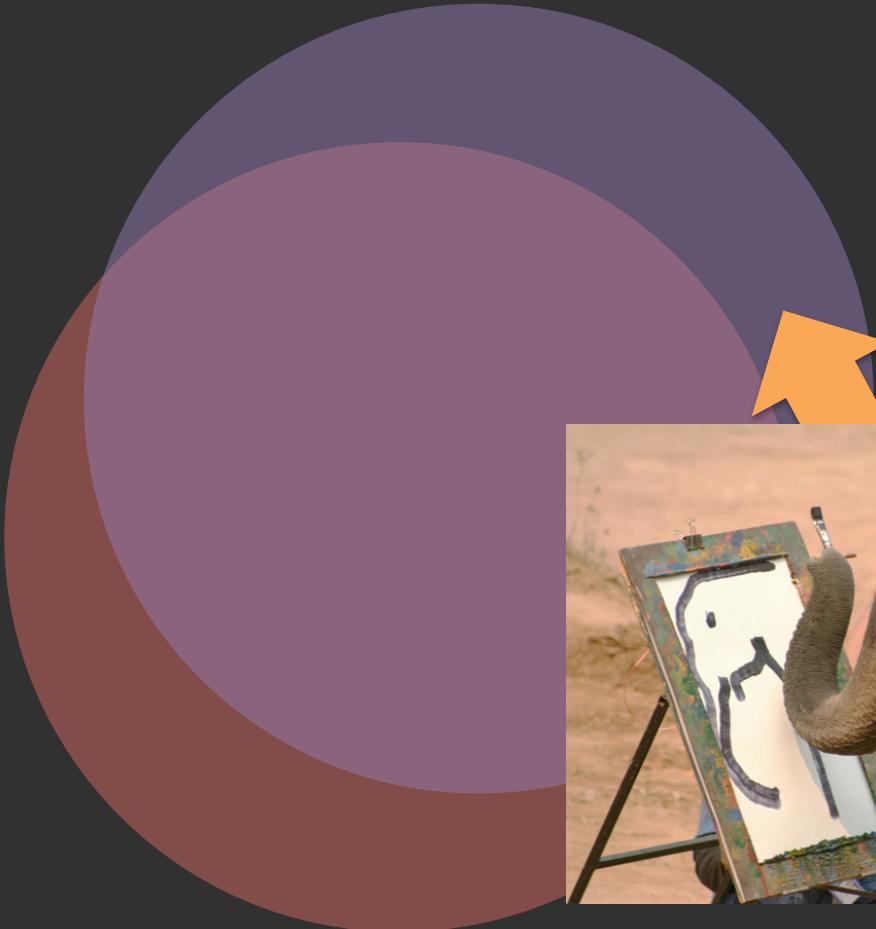




Can
Sketch

People

People



Can
Sketch





Can
Sketch

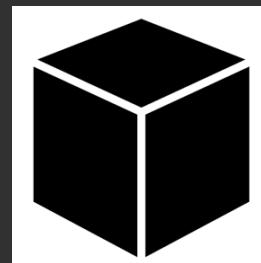
People

Can Write SQL Queries

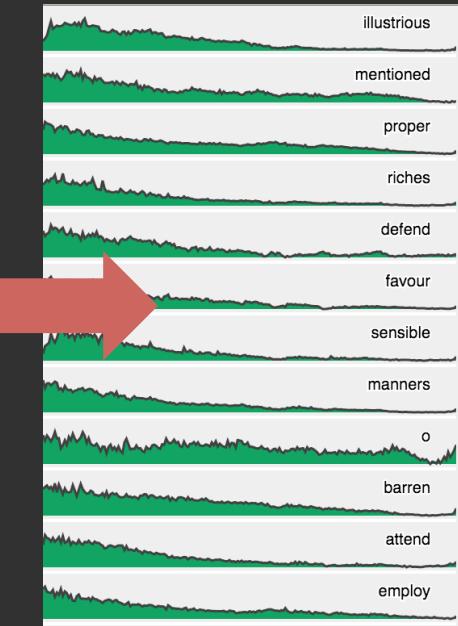
Results



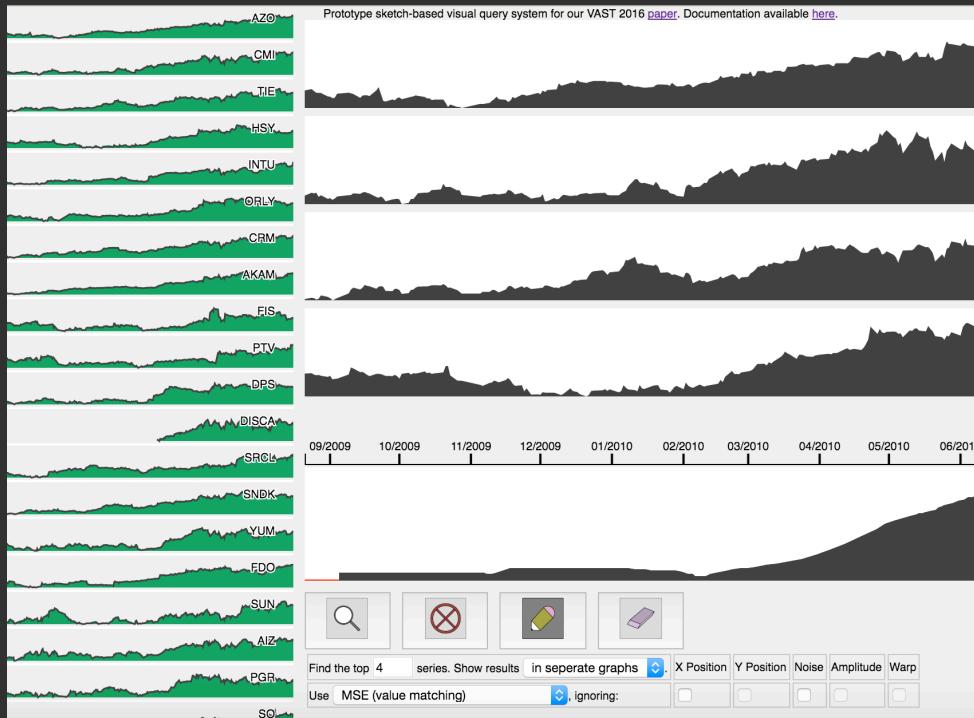
Sketch



Matching
Algorithm



github.com/uwgraphics/SketchQuery



Argument

✓ Sketching can be useful for querying

BUT

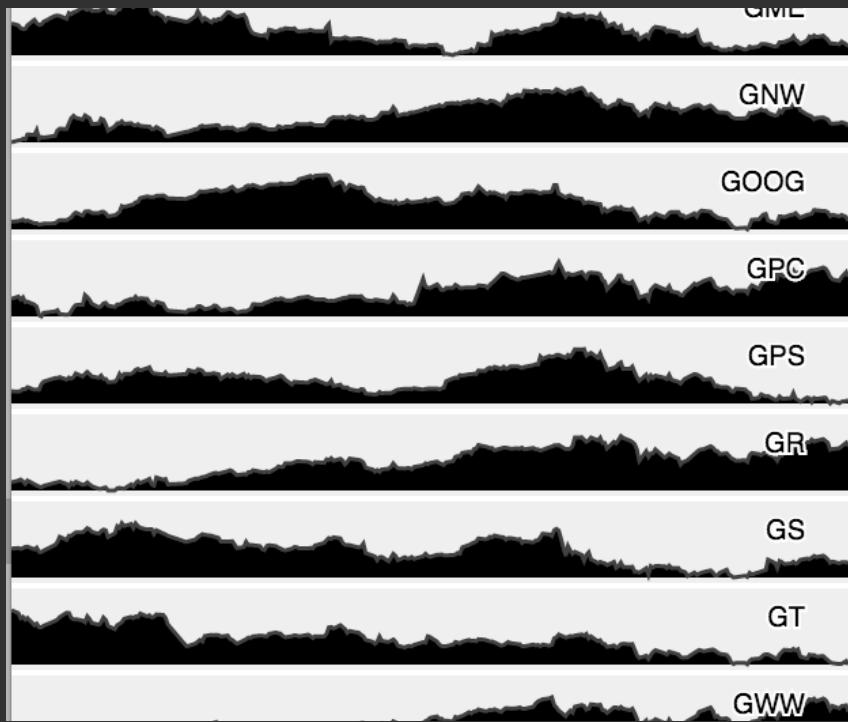
We need “invariant-aware” queries

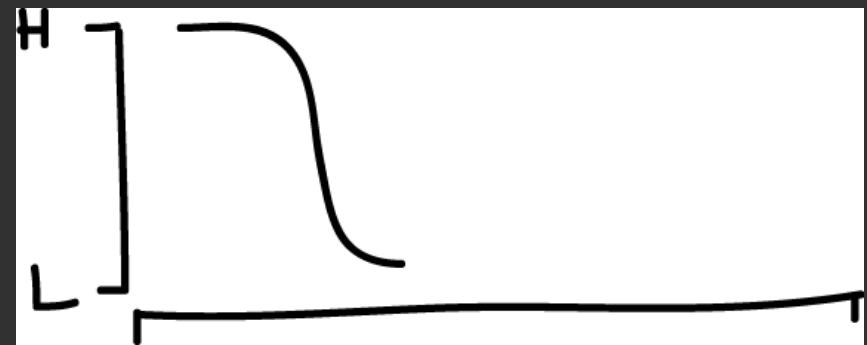
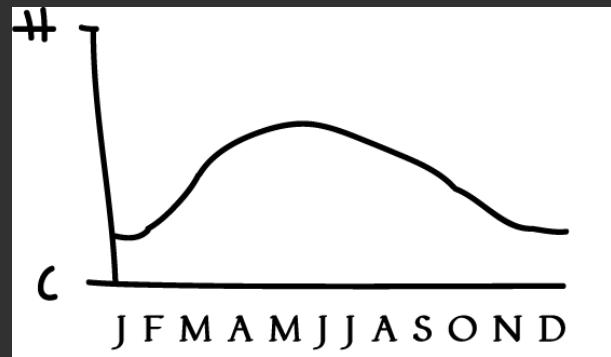
Argument

Sketch can be useful for querying

BUT

We need “invariant-aware” queries

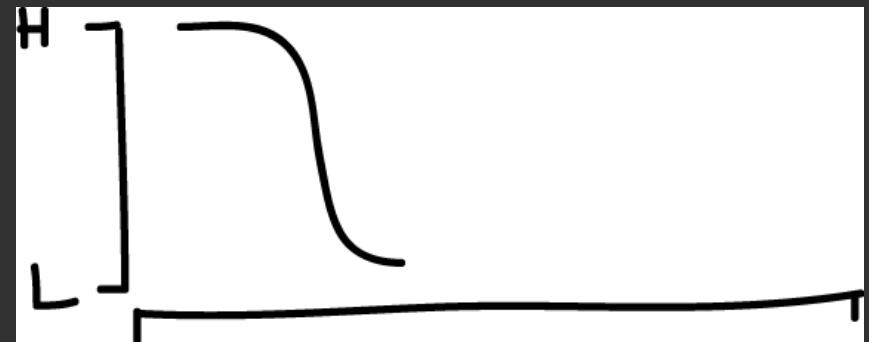




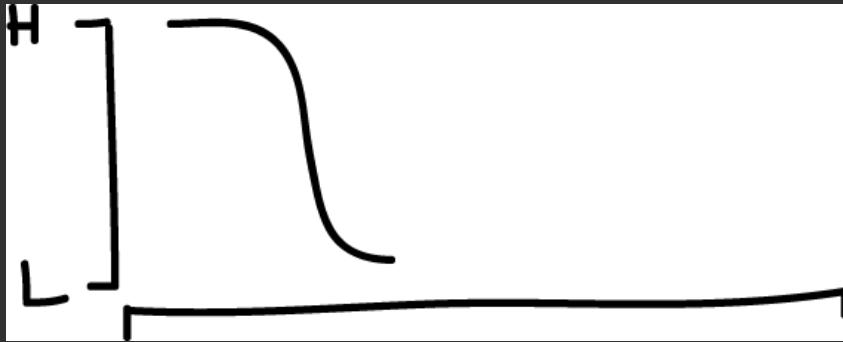
"Show me something as close as possible
to this pattern, at this location"



"Show me something as close as possible
to this pattern, at this location"



"Show me something as close as possible
to this pattern, at this location"



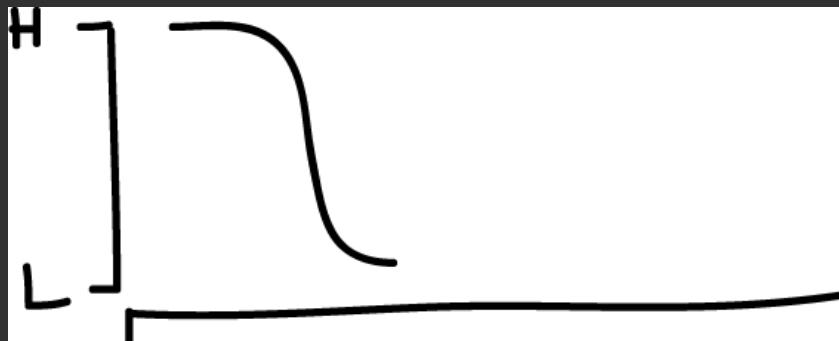
"Show me something as close as possible
to this pattern,~~at this location~~"



JNJ



"Show me something as close as possible
to this pattern, at this location"



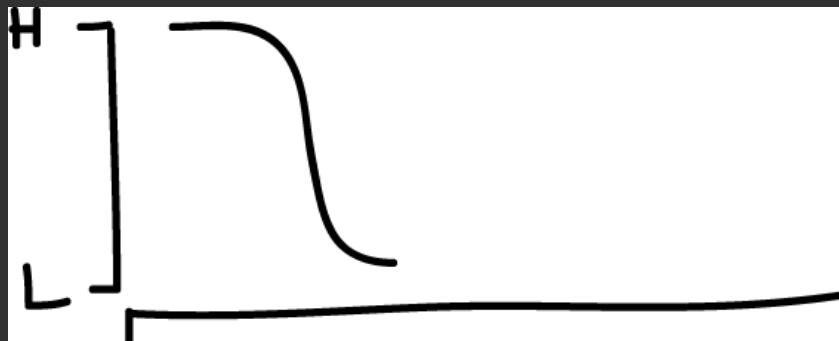
JNJ



DF



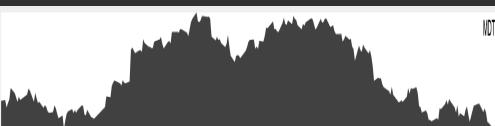
"Show me something as close as possible
to this pattern, at this location"



JNJ



DF



~~"Show me something as close as possible
to this pattern, at this location"~~



JNJ



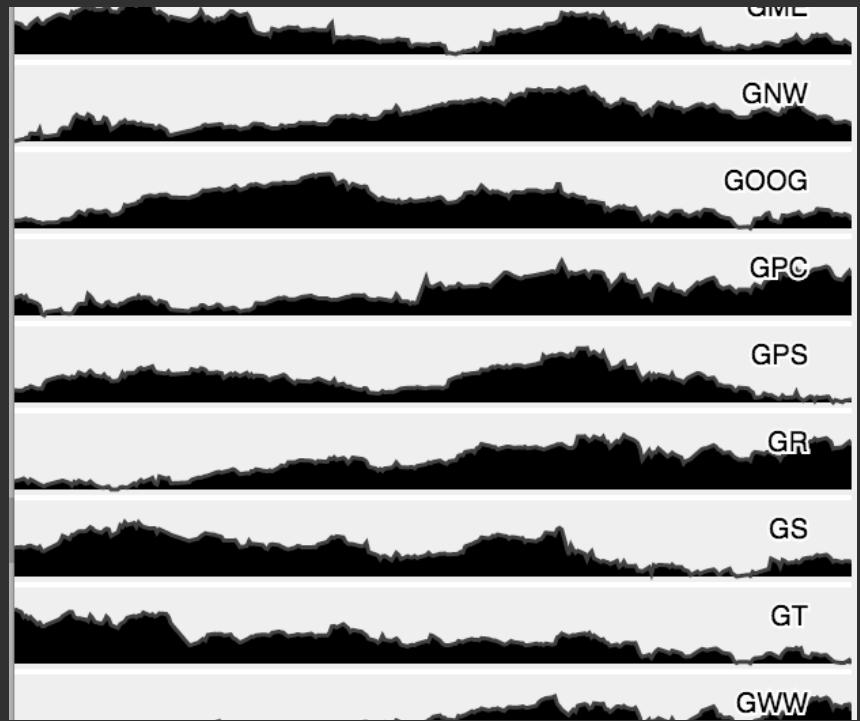
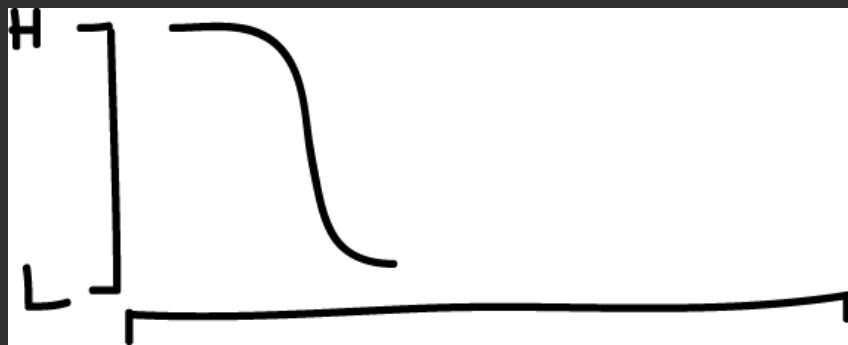
DF



BDX



Show me something?



- I. We can care about different things.
 - II. What we care about isn't always visible in the sketch.
- The **same sketch** can have **different meanings**

Invariants

"An invariant is a property of either the sketched query or the target that the analyst considers *irrelevant* for determining similarity"

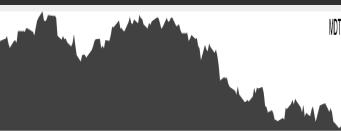
Invariant to Temporal Position



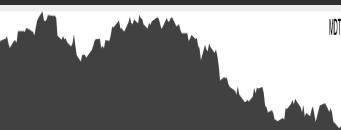
Invariant to Temporal Position



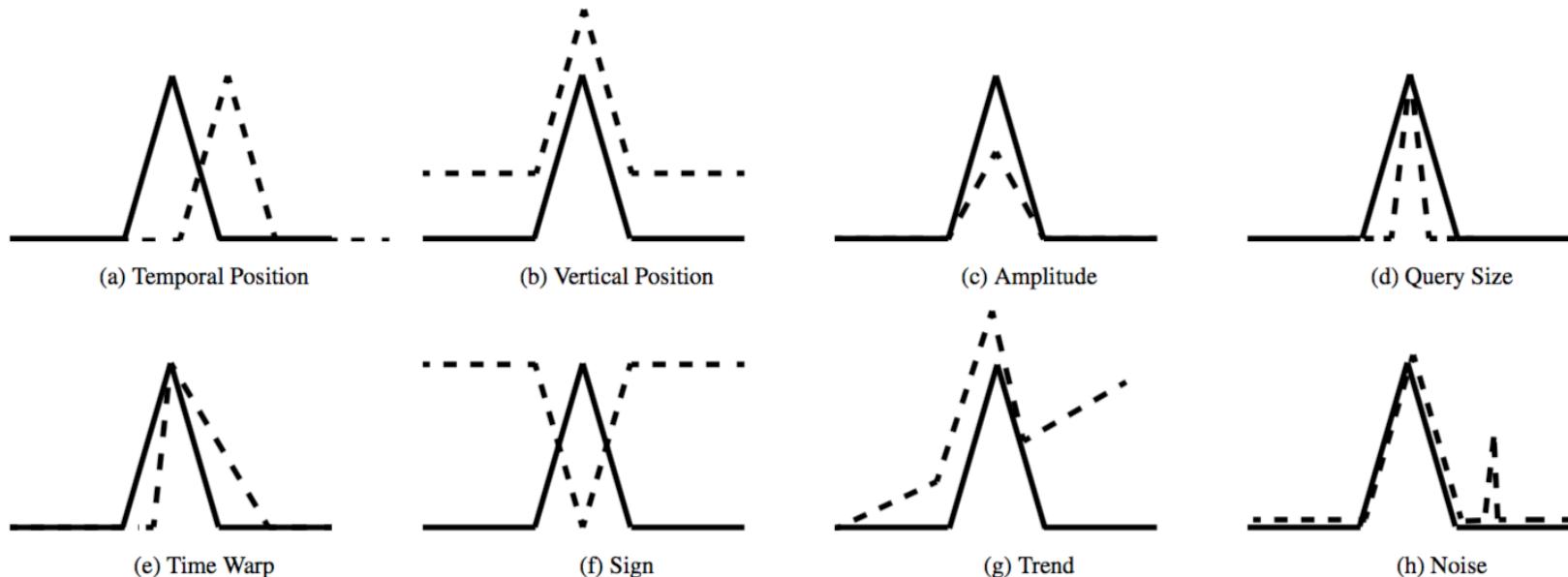
Invariant to Time Warp



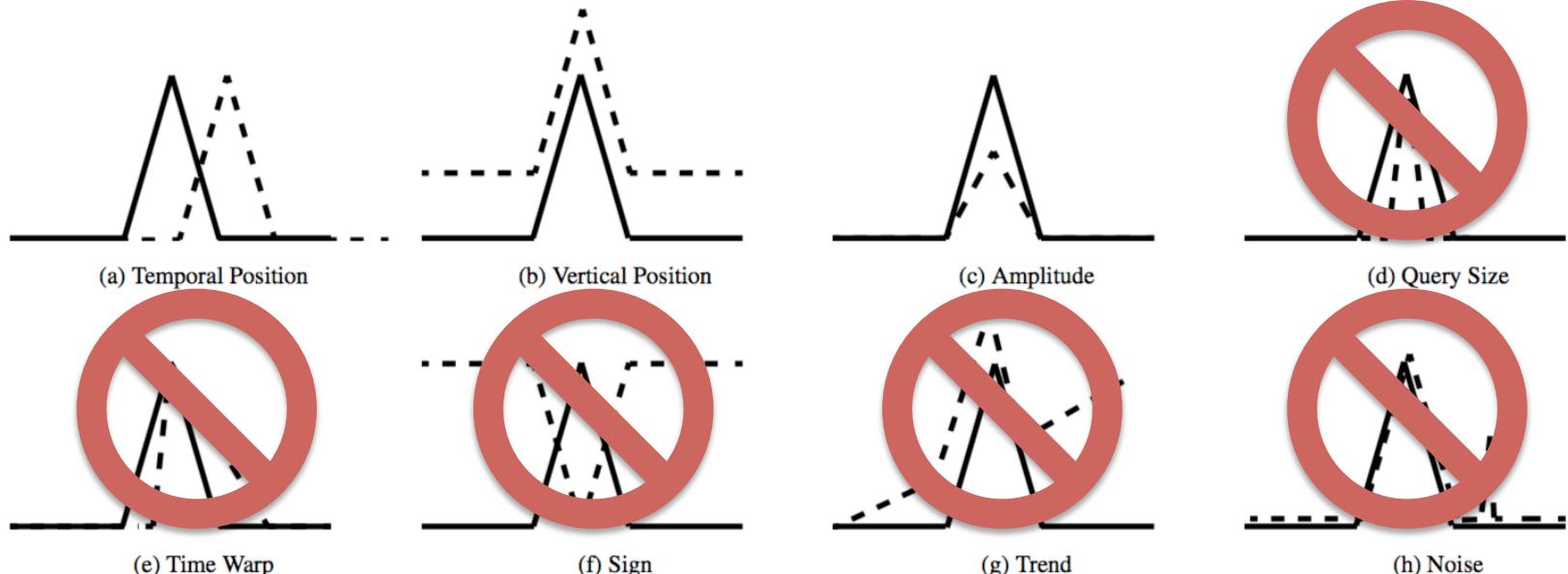
Invariant to Time Warp



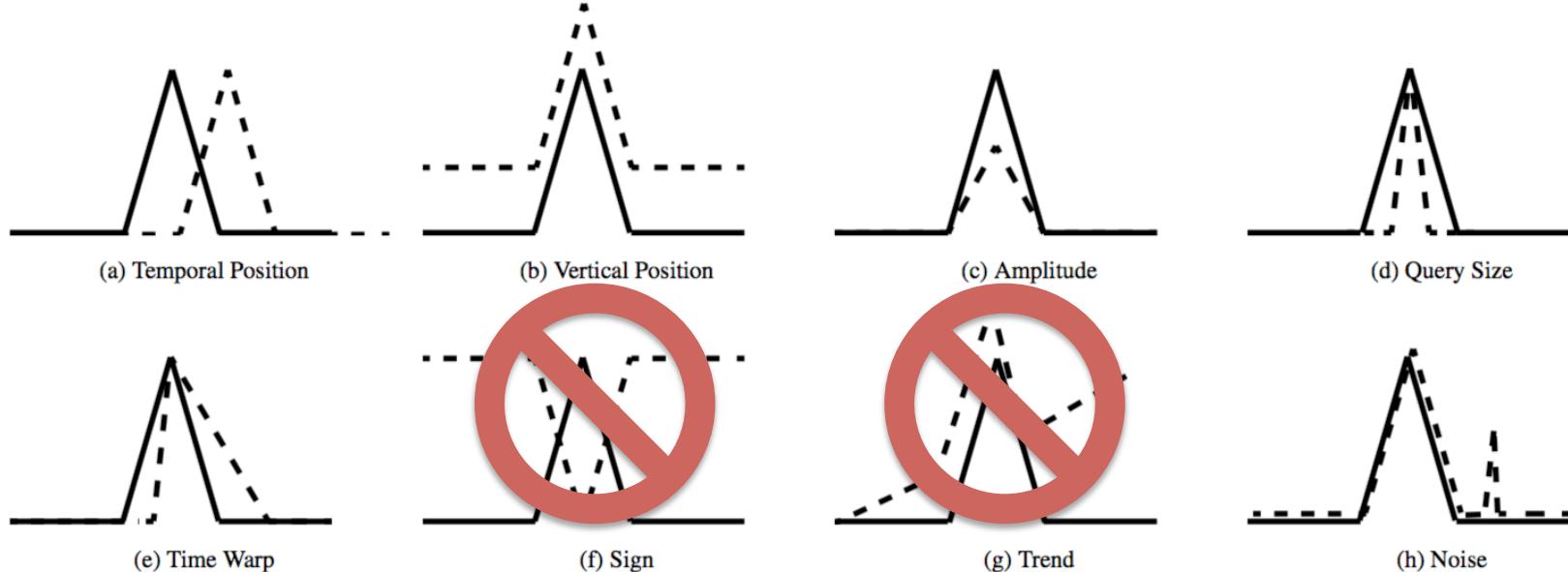
Invariants



“Show me all the crashes”



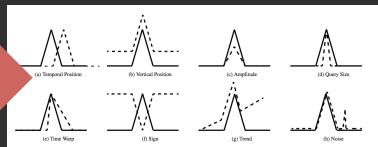
"Show me all the declines"



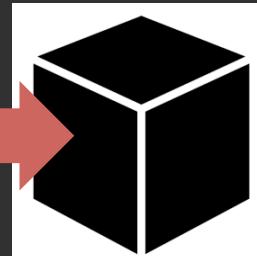
Results



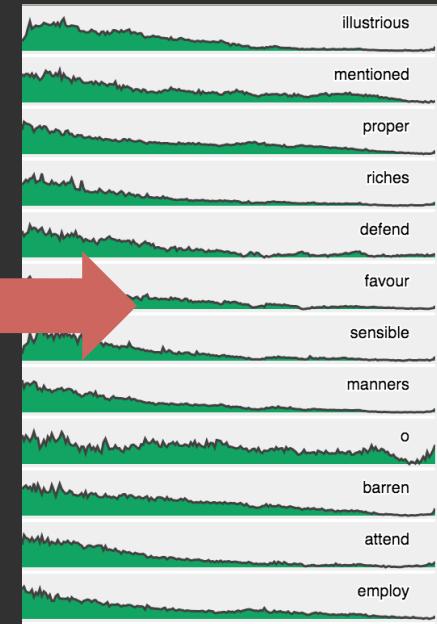
Sketch



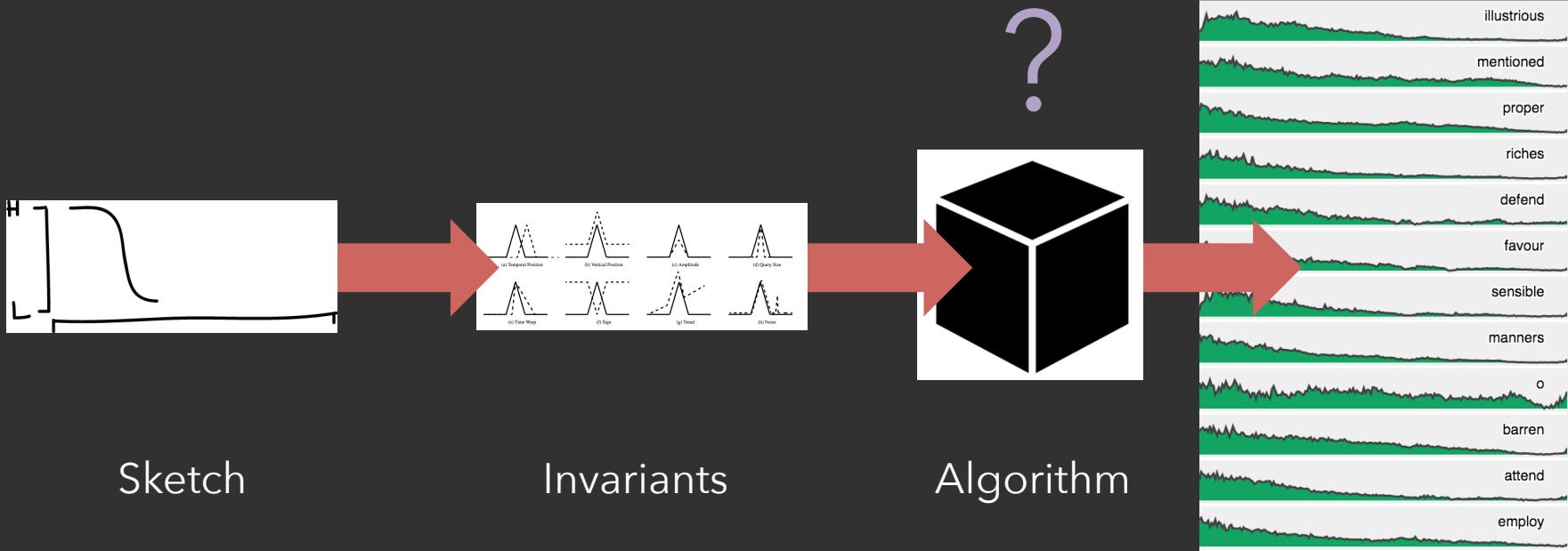
Invariants

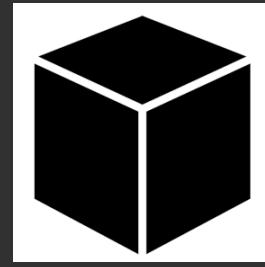


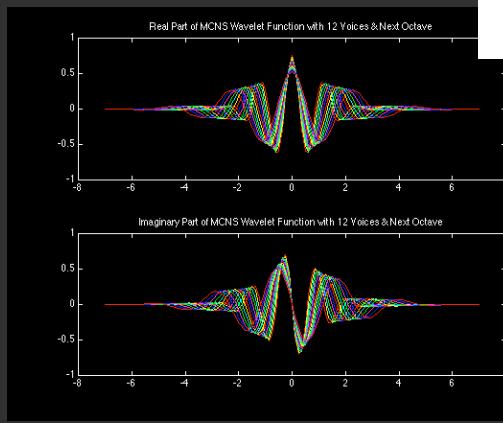
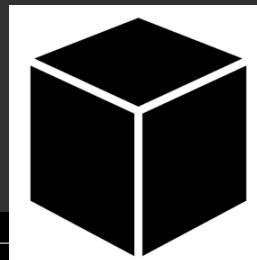
Algorithm

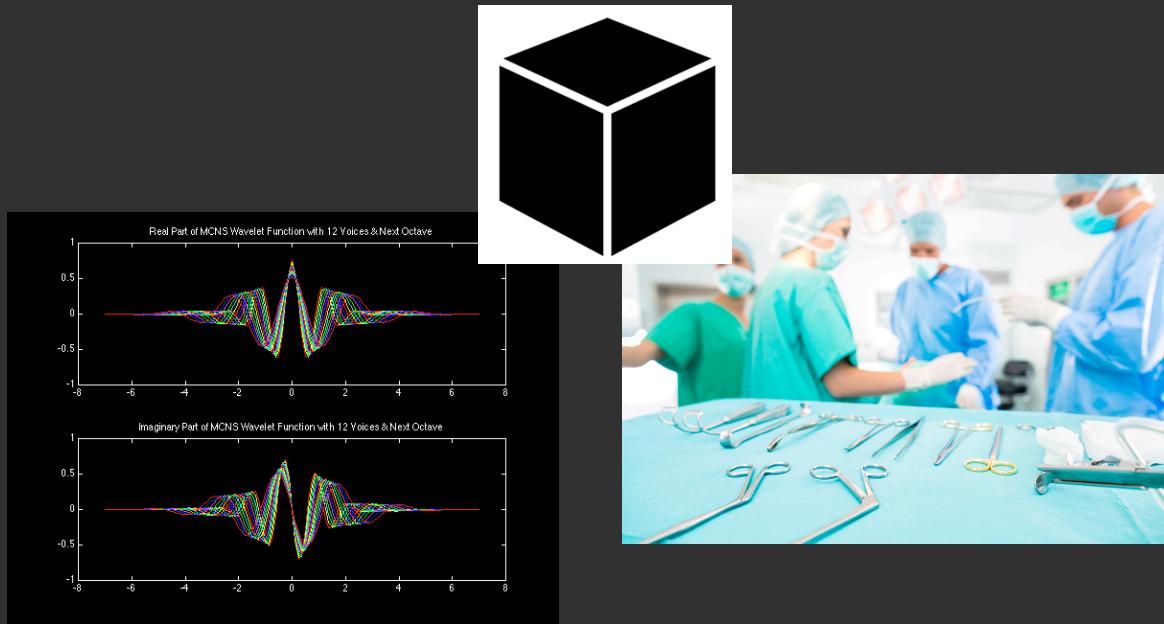


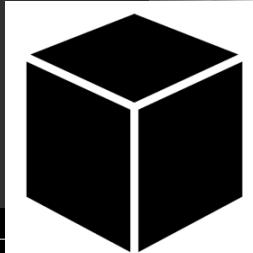
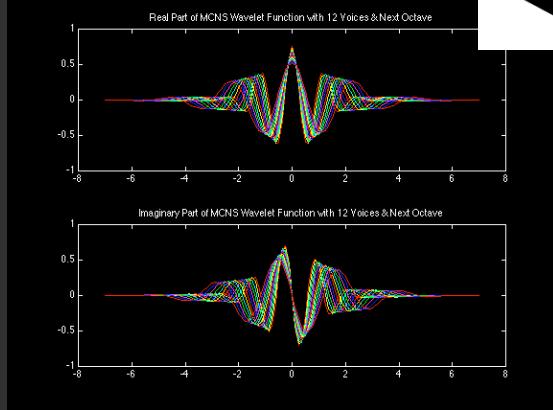
Results

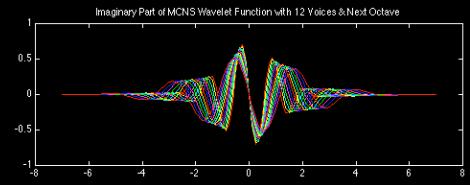
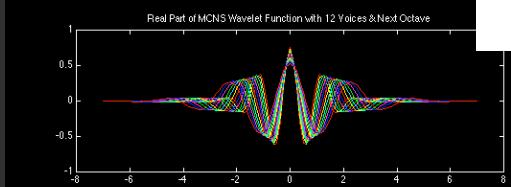
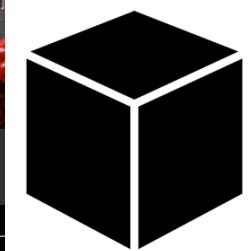






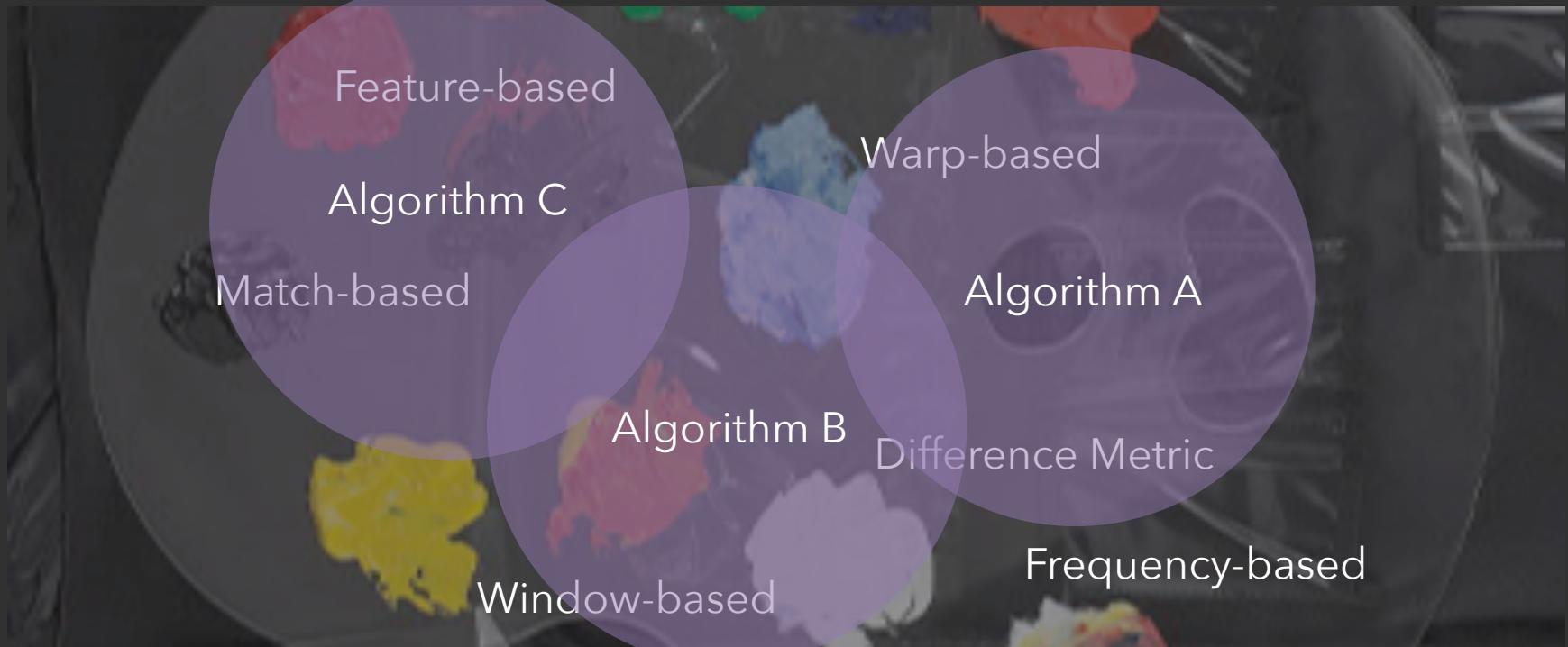












Feature-based

Algorithm C

Match-based

Warp-based

Algorithm A

Difference Metric

Frequency-based

Algorithm B

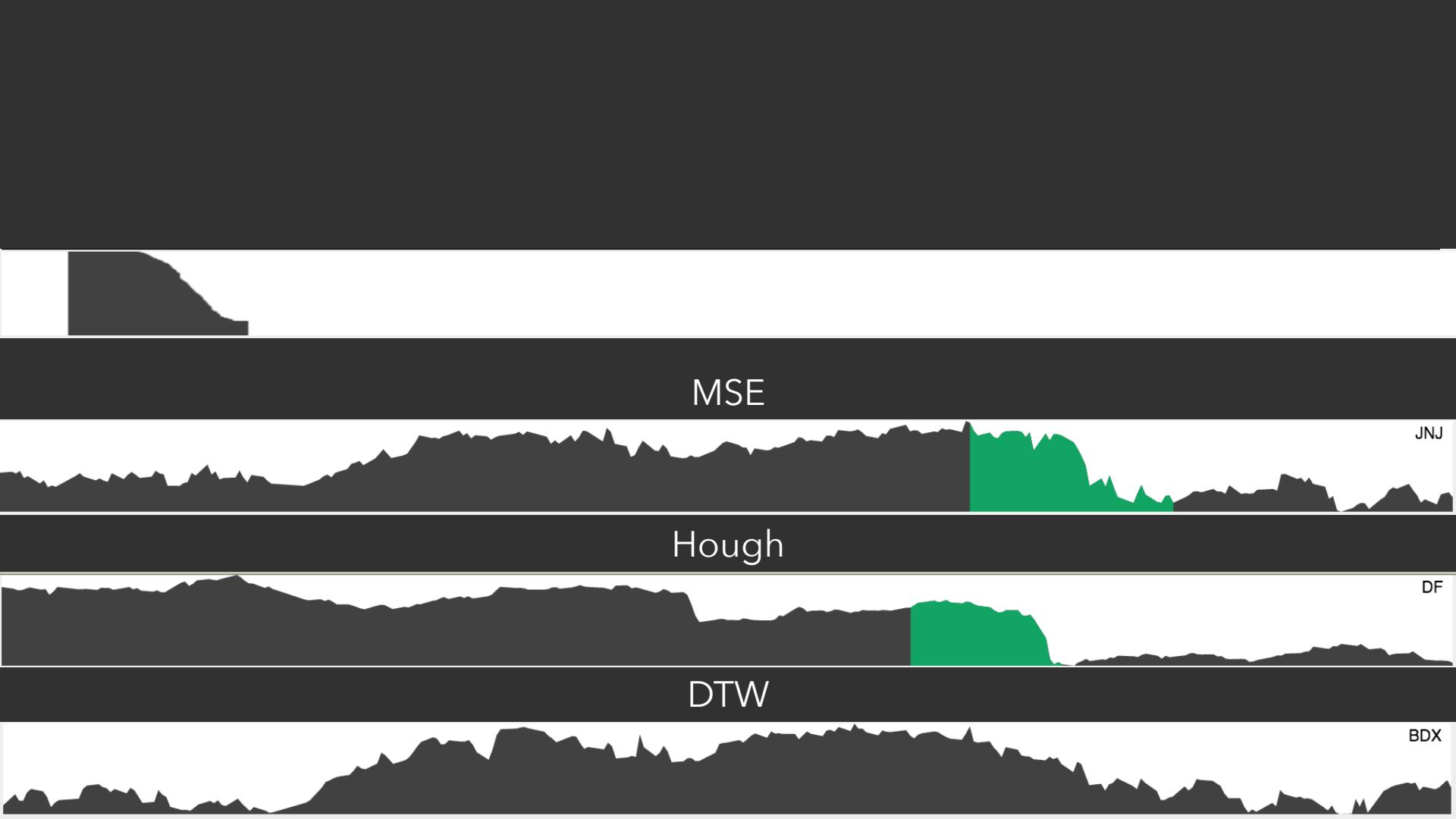
Window-based

- I. Invariants are associated with different visual features.
 - II. Different algorithms are better at matching different visual features.
- . We need multiple algorithms.

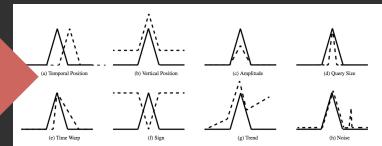
Mean Squared Error: "how different are the values in these two time series?"

Hough Voting: "how different are the shapes in these two time series?"

Dynamic Time Warping: "how much do I have to warp these two time series to get the best match?"

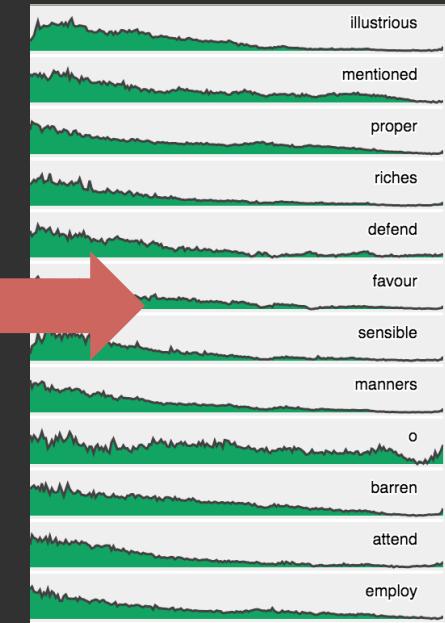
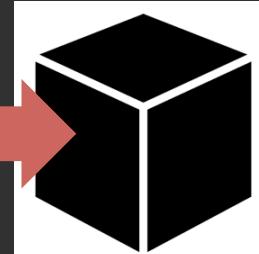


Results

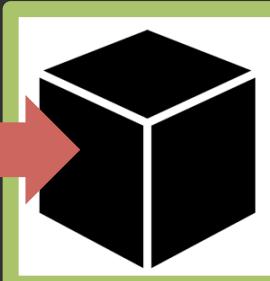
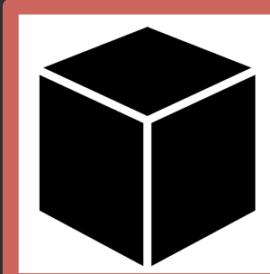
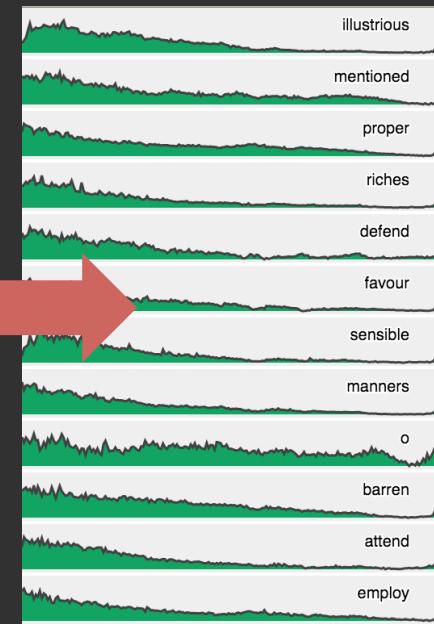


Sketch

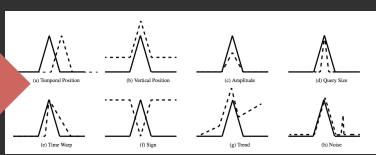
Invariants



Results

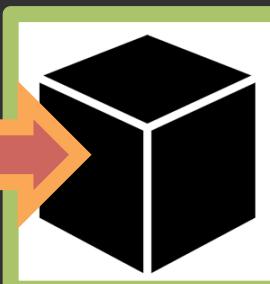
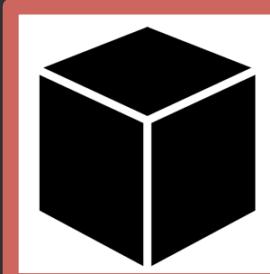
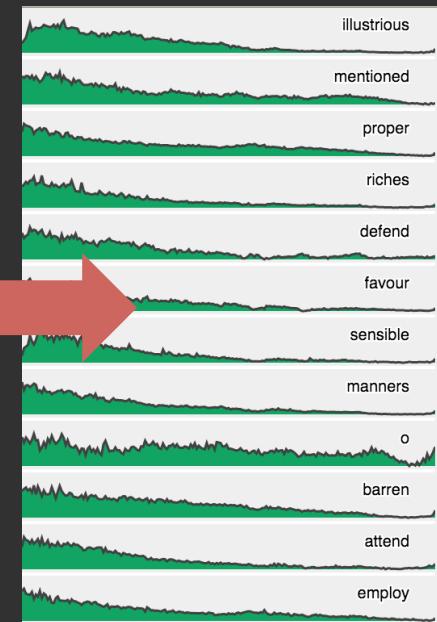


Sketch

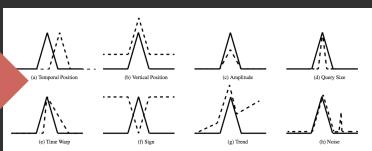


Invariants

Results



Sketch



Invariants

Open Questions

Do invariants show up in the real world?

Do I have to handle all of them, all of the time?

Do can I make informed a priori choices of invariants?

Crowd-sourced Study

Given a **target**

Change a **feature**

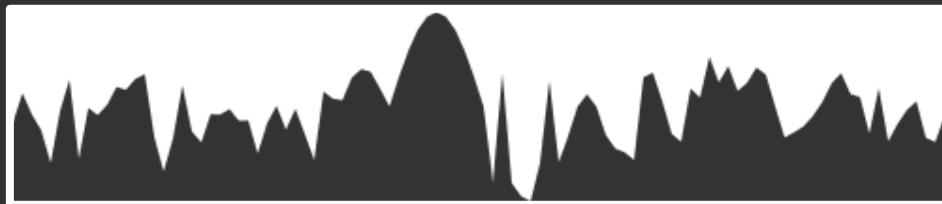
Assess the goodness of the **match**

Crowd-sourced Study

Target: Sine wave



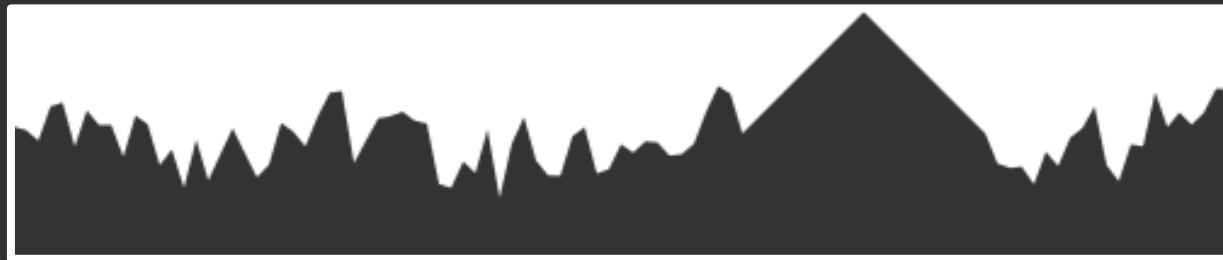
Applied **Feature:** Noise



We care a lot about amplitude



We care less about position



Results

Invariants exist in the wild

Results

Invariants exist in the wild

...but not all are equally active

Results

Invariants exist in the wild

...but not all are equally active

...and there are individual differences

Lessons

We need to handle invariants.

Different invariants = different algorithms

Different invariants = different priority

Thanks!

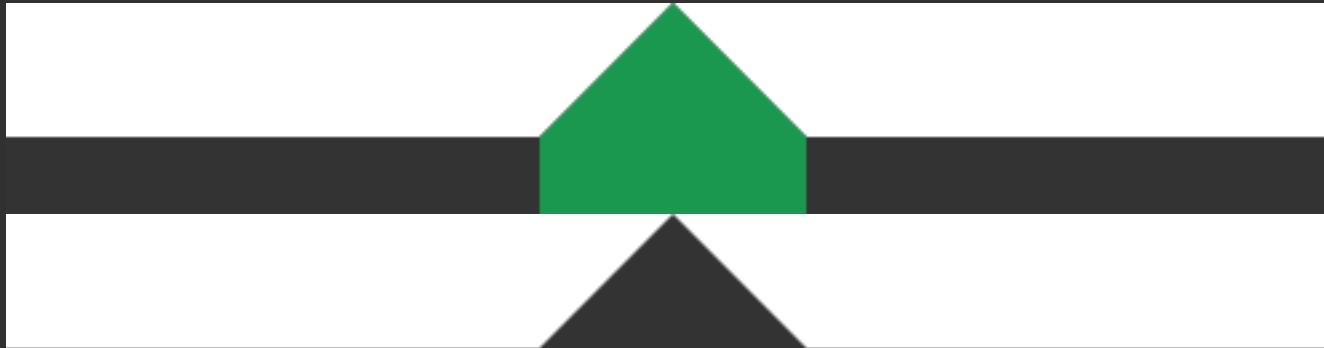
This work was supported by a grant from the Andrew W. Mellon Foundation, a Moore Foundation Data-Driven Discovery Investigator award, and NSF award 1162037.

System demo, source code, and data available at:
github.com/uwgraphics/SketchQuery

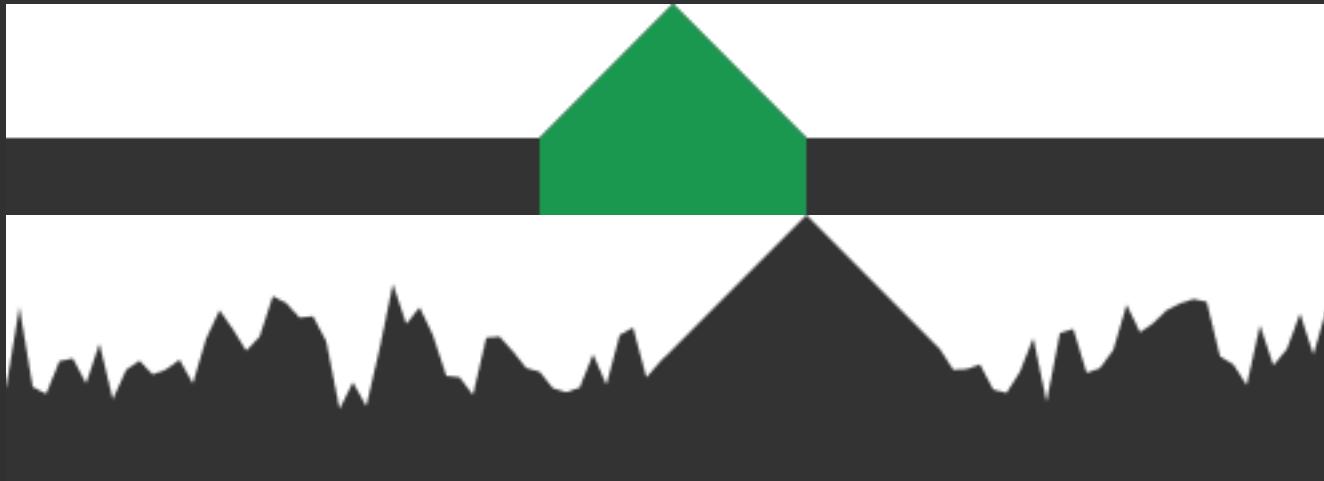


Extra Slides

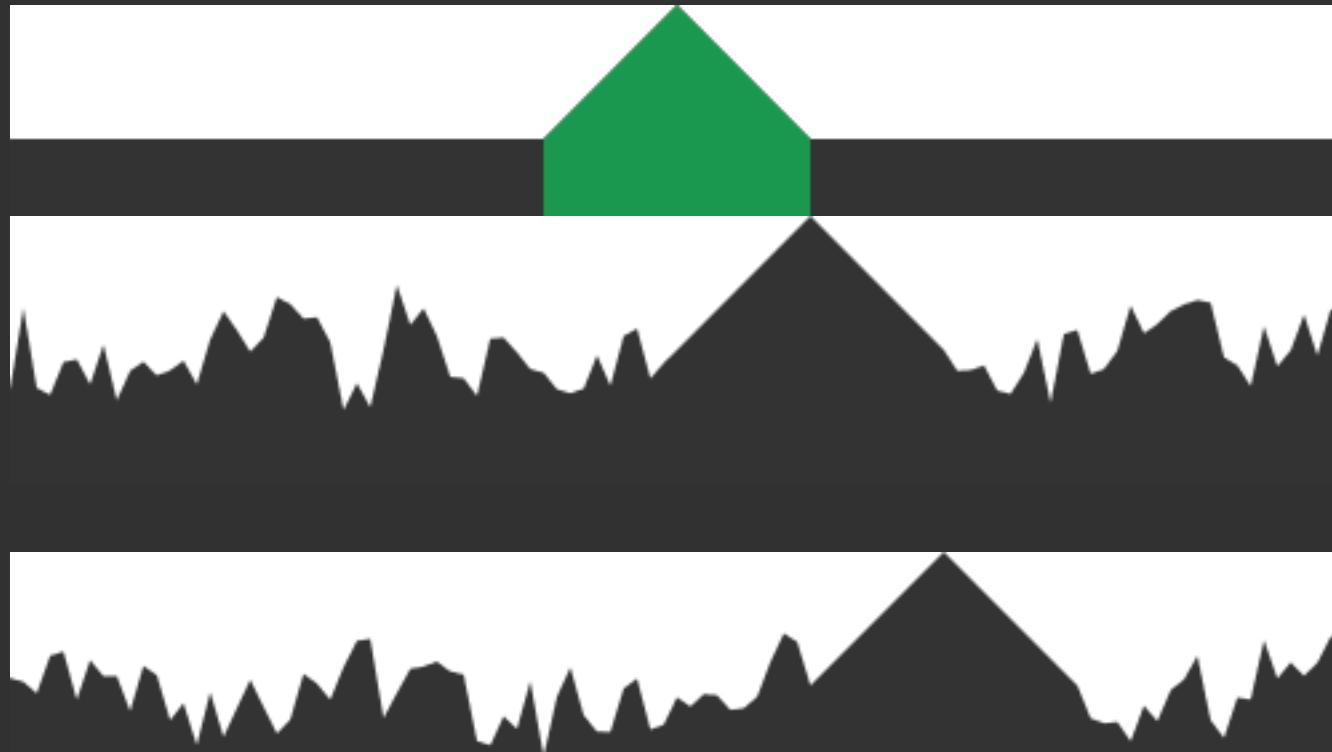
What do people care about?



What do people care about?

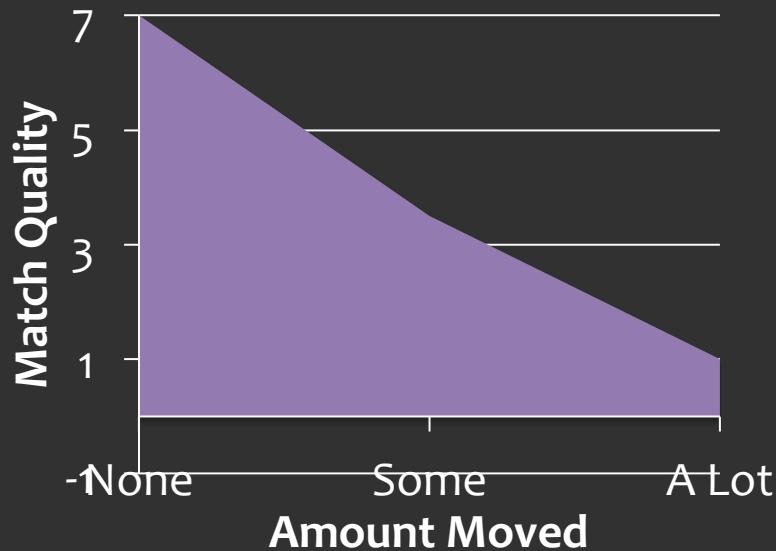


What do people care about?



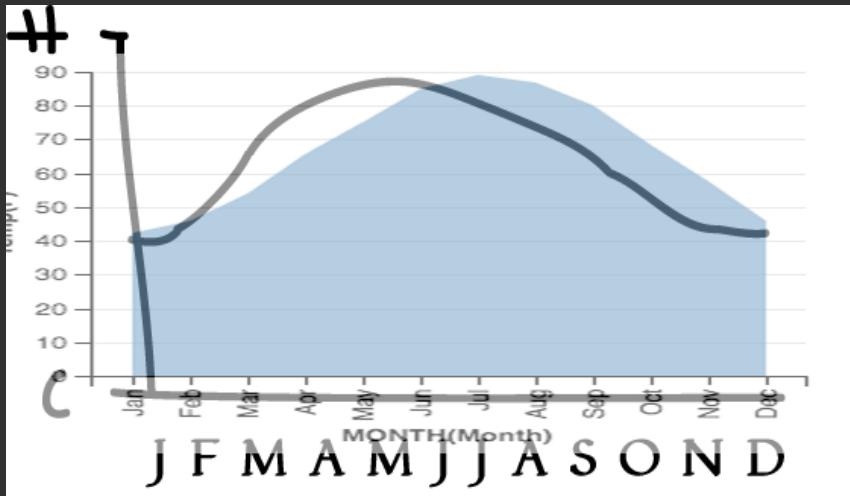
Two Scenarios

I care about this!



I don't care about this!

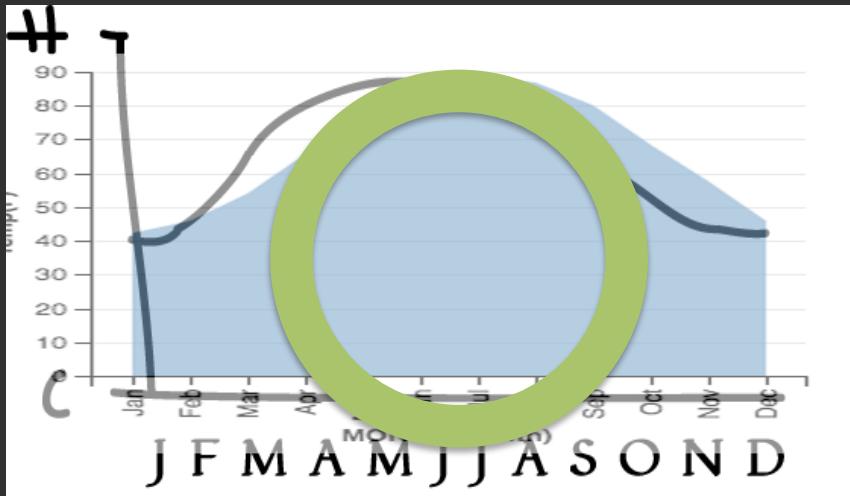




```
INSERT INTO Query VALUES  
40,50,65,80,90,85,75,70,65,55,4  
5,40;
```

```
SELECT Month,(Query.temp-  
Climate.temp) AS diff FROM  
Climate,Query JOIN ON  
Query.month=Climate.month  
WHERE  
Climate.City="Baltimore";
```

...



```
INSERT INTO Query VALUES  
40,50,65,80,90,85,75,70,65,55,4  
5,40;
```

~~SELECT Month,(Query.temp - Climate.temp) AS diff FROM Climate,Query JOIN ON Query.month=Climate.month WHERE Climate.City='San Jose';~~

...

Crowd-sourced Study

Example: Amplitude

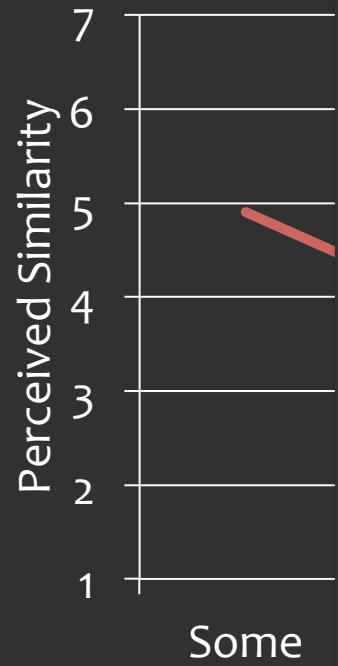


Crowd-sourced Study

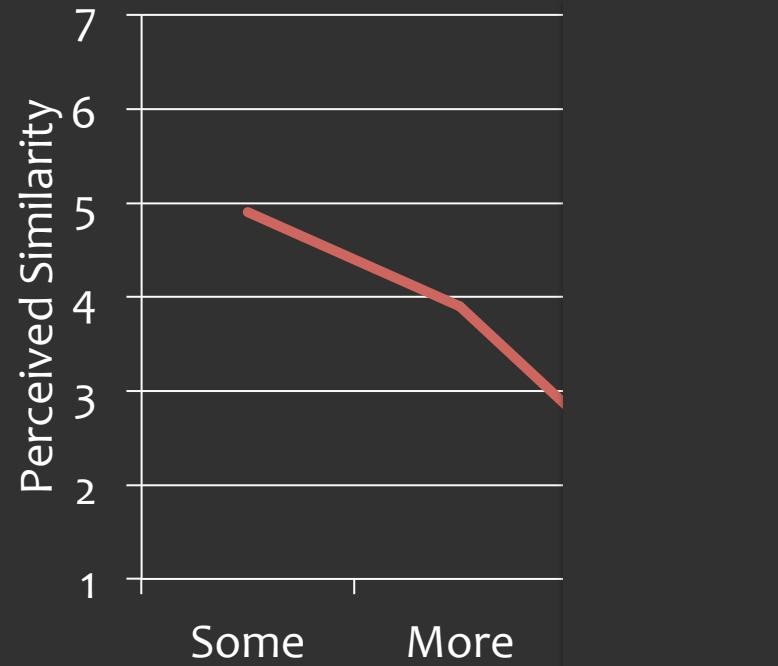
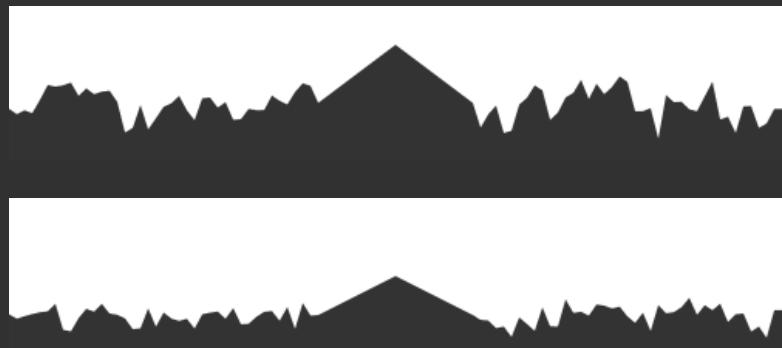
Example: Amplitude



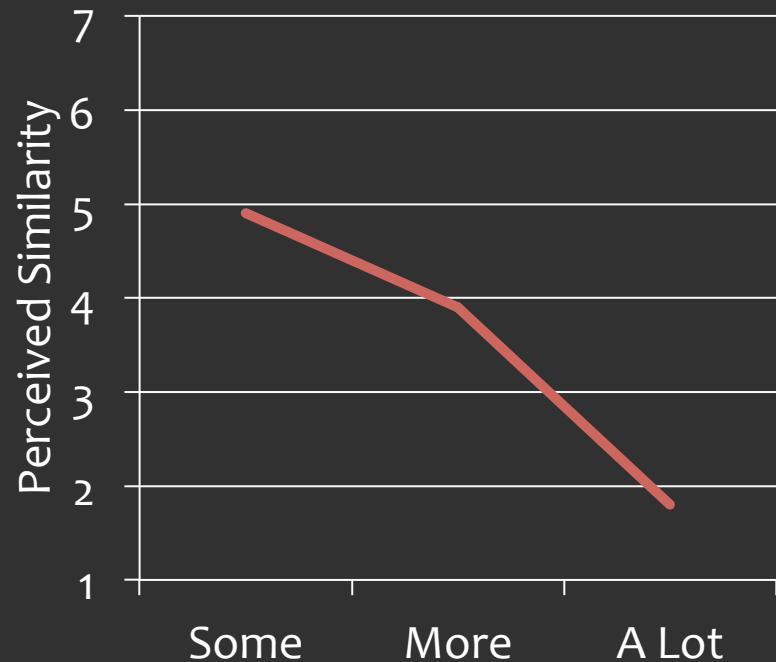
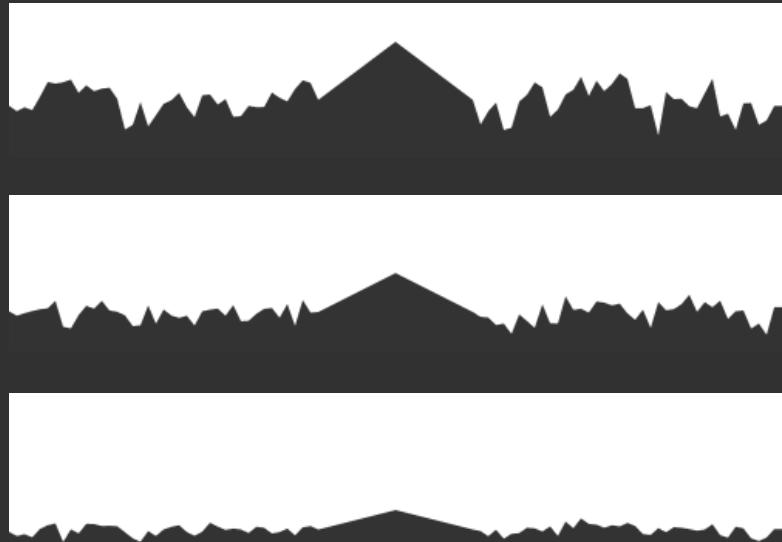
Do People Care About Amplitude?



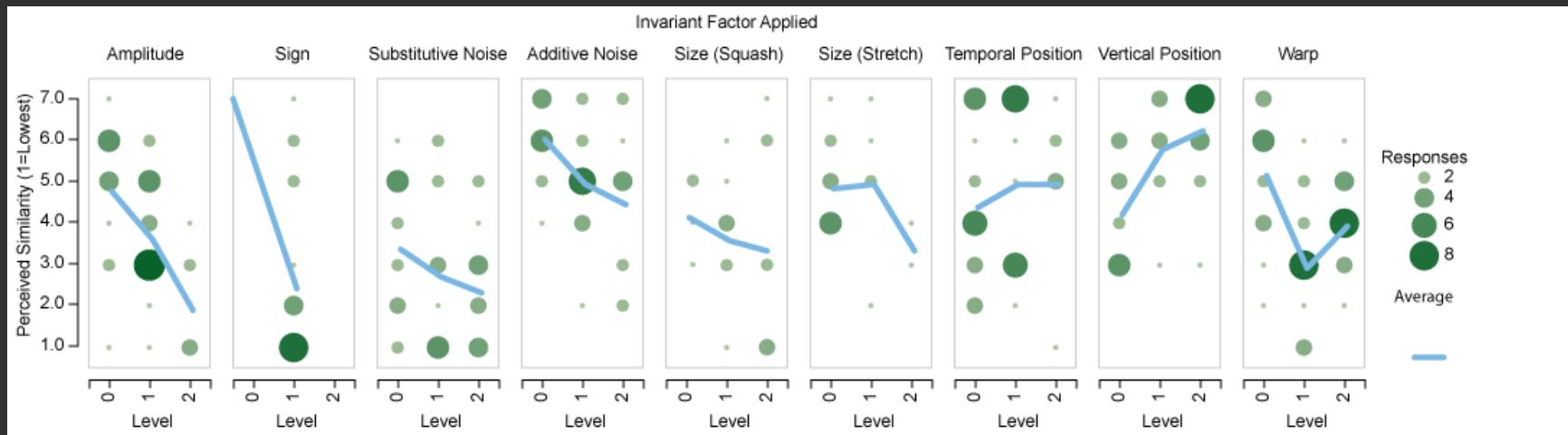
Do People Care About Amplitude?



Do People Care About Amplitude?



People Have Diverse Invariants



Algorithms Have Diverse Invariants

