Diving into an ocean of biological motions: Clustering of perceived attributes

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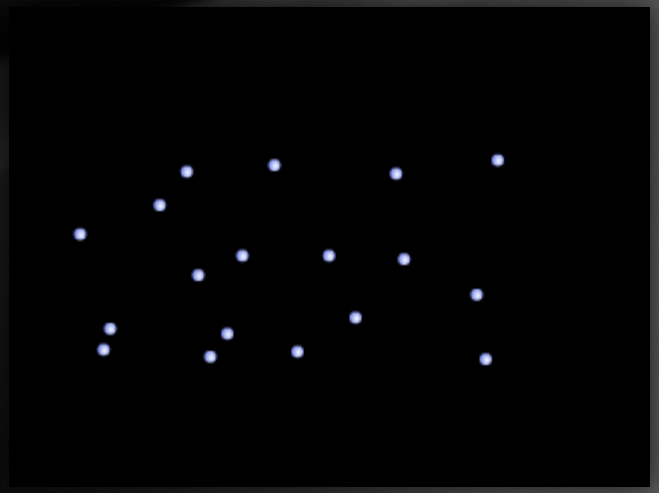
What is biological motion?

Movement patterns of animals and humans

- Detect presence of another living being, instead of an inanimate object in environment.

Studied using point-light motion: dot placed on major joints of the body human/animal. Also gives rise to an organized percept of a living creature (Johansson,1973)



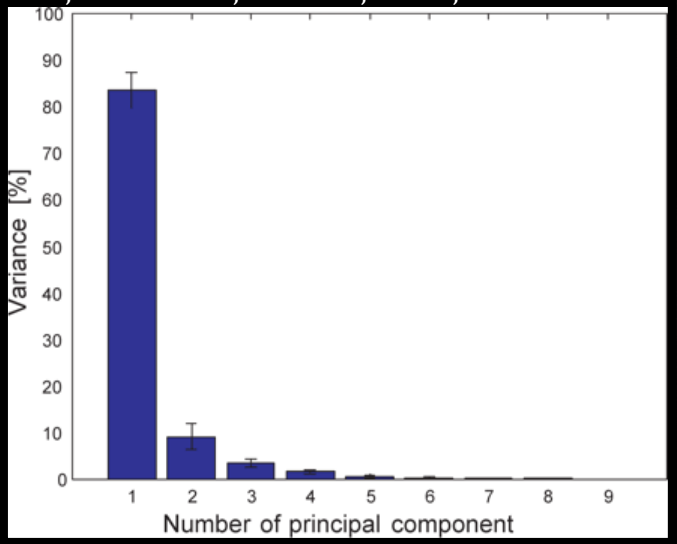
Decomposing biological motion

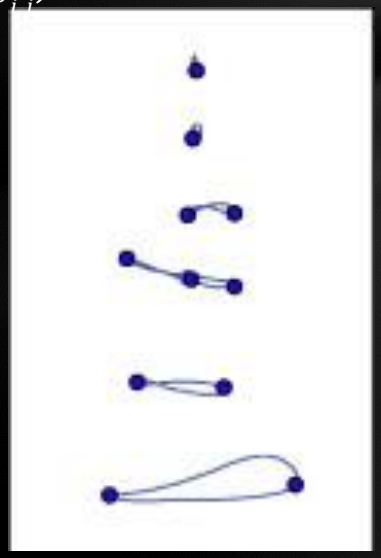
$P = (m1_x, m1_y, m1_z, m2_x, \ldots m15_z)^T$

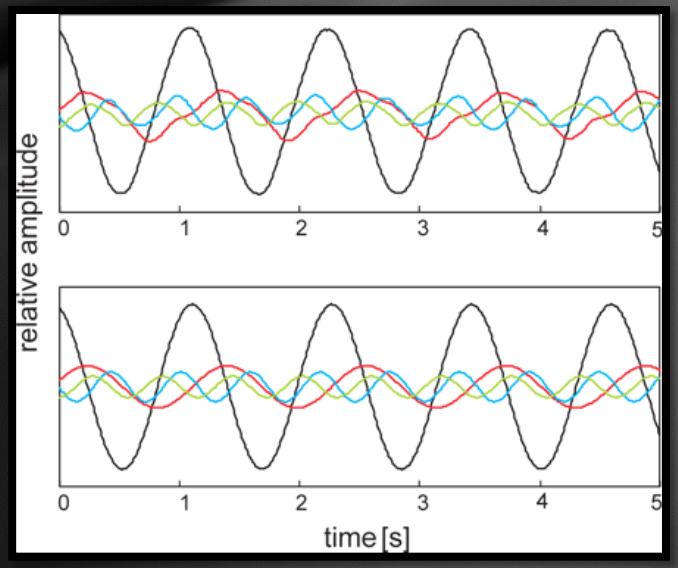
$P_i(t) = pi_{,o} + pi_{,1} \sin(\omega_i t) + qi_{,1} \cos(\omega_i t) + pi_{,2} \sin(2\omega_i t) + qi_{,2} \cos(2\omega_i r) + \cdots p_{i,n} \sin(n\omega_i t) + qn_{,1} \cos(n\omega_i t)$

$\omega = 2\pi f$

$a_{i,j} = \sqrt{p^2_{i,j} + q^2_{i,j}}, \varphi_{i,j} = arctan\left(\frac{q_{i,i}}{p_{i,i}}\right)$







What is biomotion?

4 Steps of information processing of biological motion perception

- Detection of animate motion
- Structure from motion
- Action perception
- Style recognition

Objective

It has been shown that a given attribute (e.g., gender) can be expressed as a linear combination of walker features (Troje, 2008).

With many more attributes, is there a low number of perceptual dimensions that can characterize them?

If so, what are they?

Data Acquisition

1. Participants *choose* an attribute to label as well as the 2 extreme states (e.g. gender: male-female; alertness : vigilant-drowsy)
2. WALKERS are presented randomly, one at a time for an infinite display time
3. Participants rate WALKER on a 6 point Likert scale
4. Participants can quit anytime (data will fewer than 20 trials will not be saved)

http://www.biomotionlab.ca/Demos/BMLrating.html

Data acquisition

Attributes: 41844 total, 8073 unique names

Testing dates: 2005-2013 (and ongoing)

date	name	gender	age	country	attribute	scale	scale2	trials	numoo	...
2/13/2008 11:35	sscovil	m	21-30	canada	funkiness	lame	groovy	33	0	...
2/13/2008 13:48	Karol	m	10-20	Poland	sporty	very maskuline	very feminine	84	1	...
2/13/2008 15:04	eve	f	31-40	usa	weight	light	heavy	60	0	...
2/13/2008 16:34	chelsie	f	10-20	united states	hi	you	me	29	0	...
2/13/2008 16:46	eve	f	31-40	usa	sleepiness	exhausted	rejuvenated	54	1	...
2/13/2008 17:53	anacleta	f	41-50	uruguay	male	f	s	26	0	...
2/13/2008 18:49	Arrg	m	10-20	United Kingdom	Weight	light	heavy	23	0	...
2/13/2008 19:02	Brian	m	10-20	United States	Emotional	Depressed	Excited	40	6	...

Analytical approach: Linear Discriminant Analysis

Decompose walkers from eigenPosture to eigenWalker space

For each attribute

Class indicator: r eigen.W. coefficient matrix: W

For a Linear Discriminant Function (LDF) d, solve

$$\mathrm{W`d} = \mathrm{r}$$

Therefore

$$\mathrm{d} = \mathrm{W}\backslash\mathrm{r}$$

LDF matrix: 10 x 40,000

Analytical Approach

Decompose LDF matrix to Eigen-linear-discriminant-functions (ELDF)

↓

Determine clusters of ELDFs in ten-dimensional space

Clustering algorithms

- K-means
- Expectation Maximization to fit Gaussian Mixture model

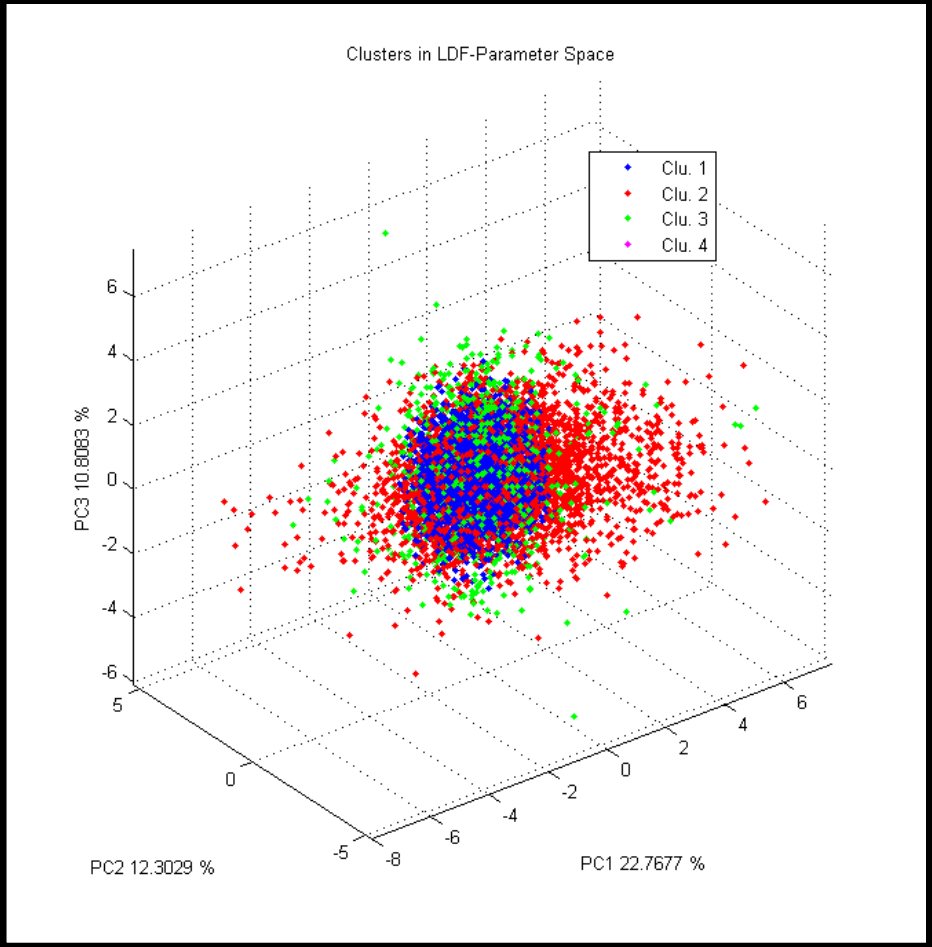
Validate and Evaluate

- Select established attribute
- Reconstruct walkers for each cluster-average

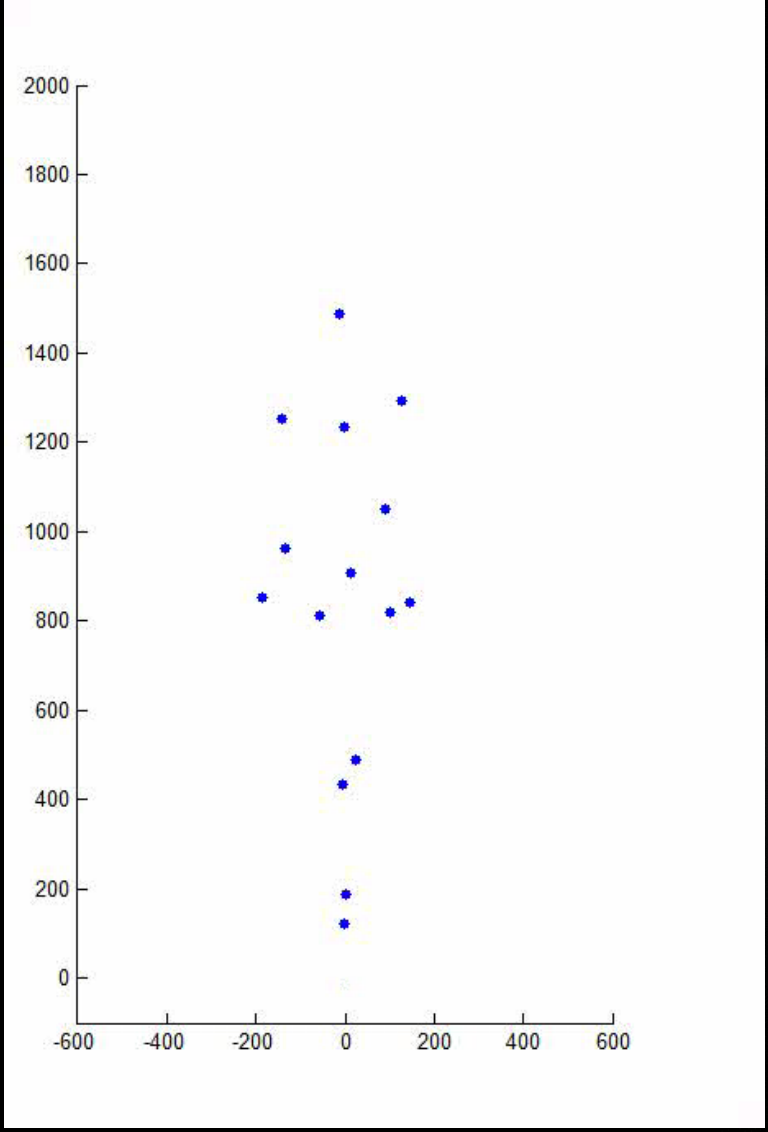
Gender attributes

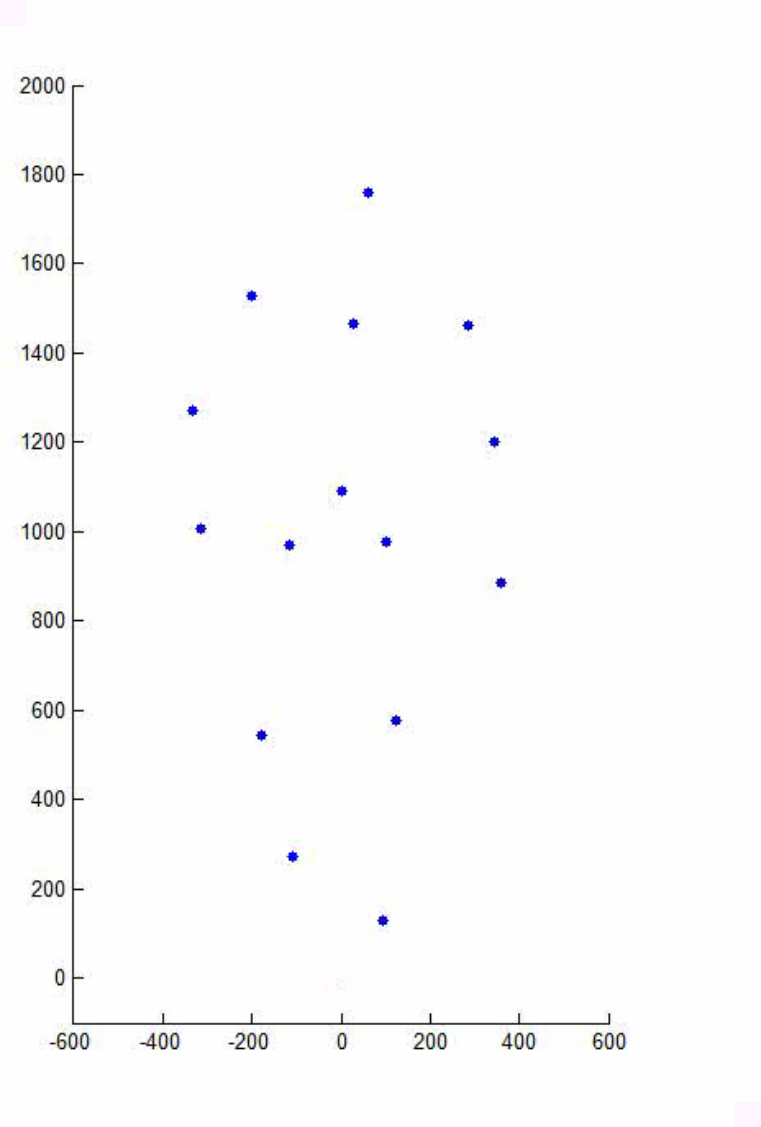
'Gender' 'Sex' 'Masculinity' 'Feminine' 'Very masculine'

- Multiple clusters
- All of them had gender characteristics BUT one

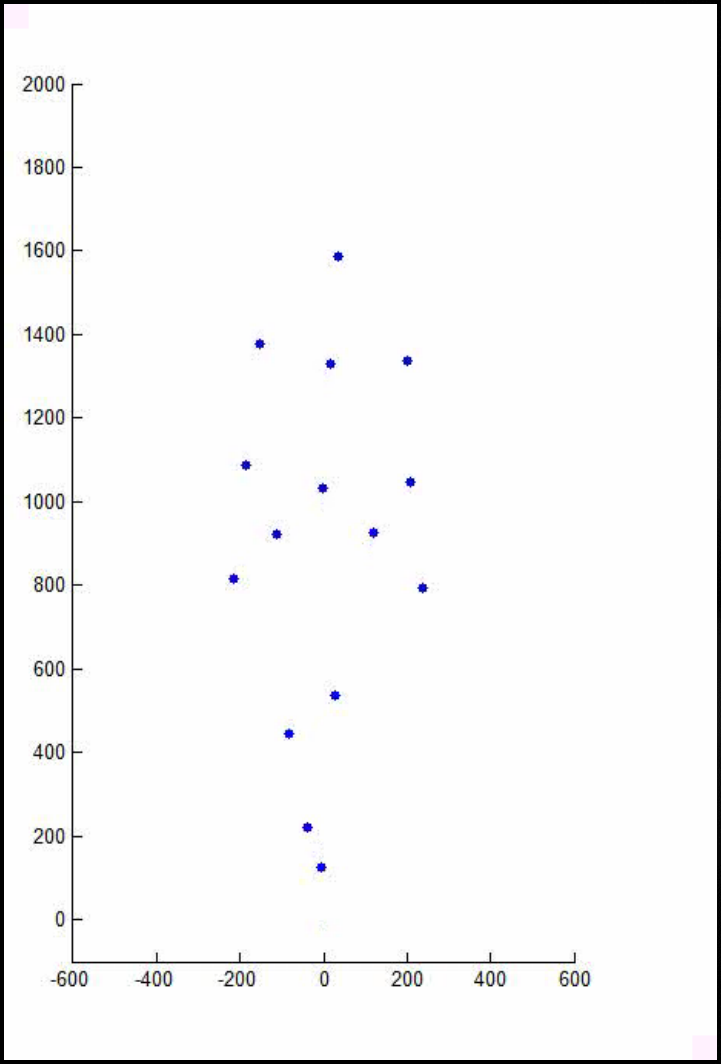


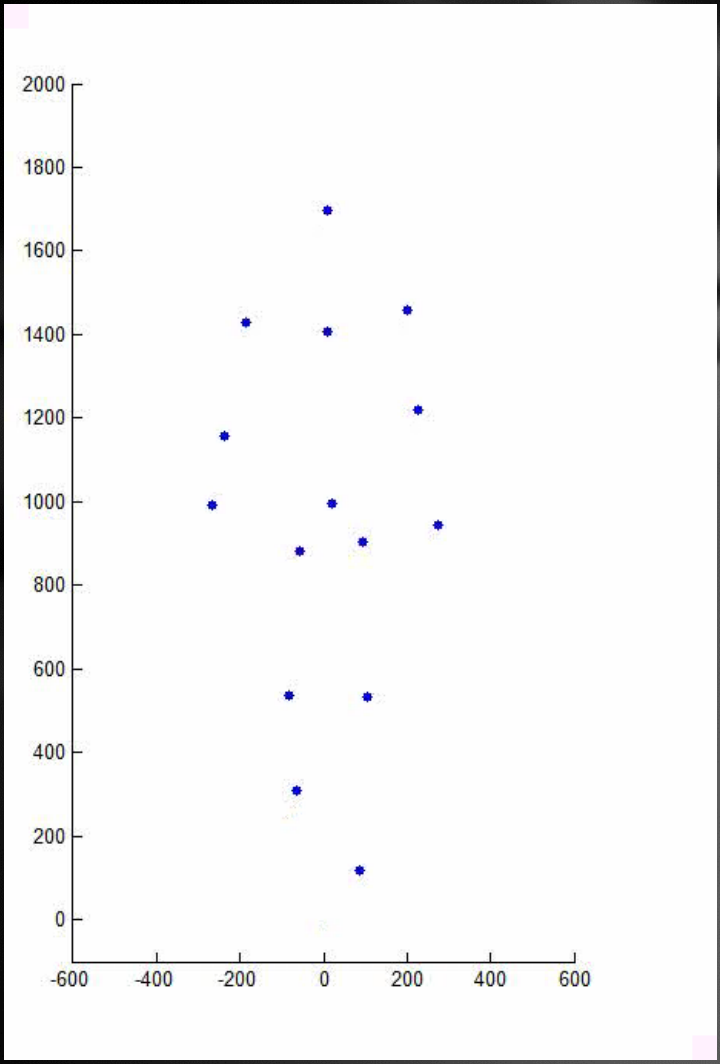
‘Gender’ Cluster





‘Vitality’ Cluster

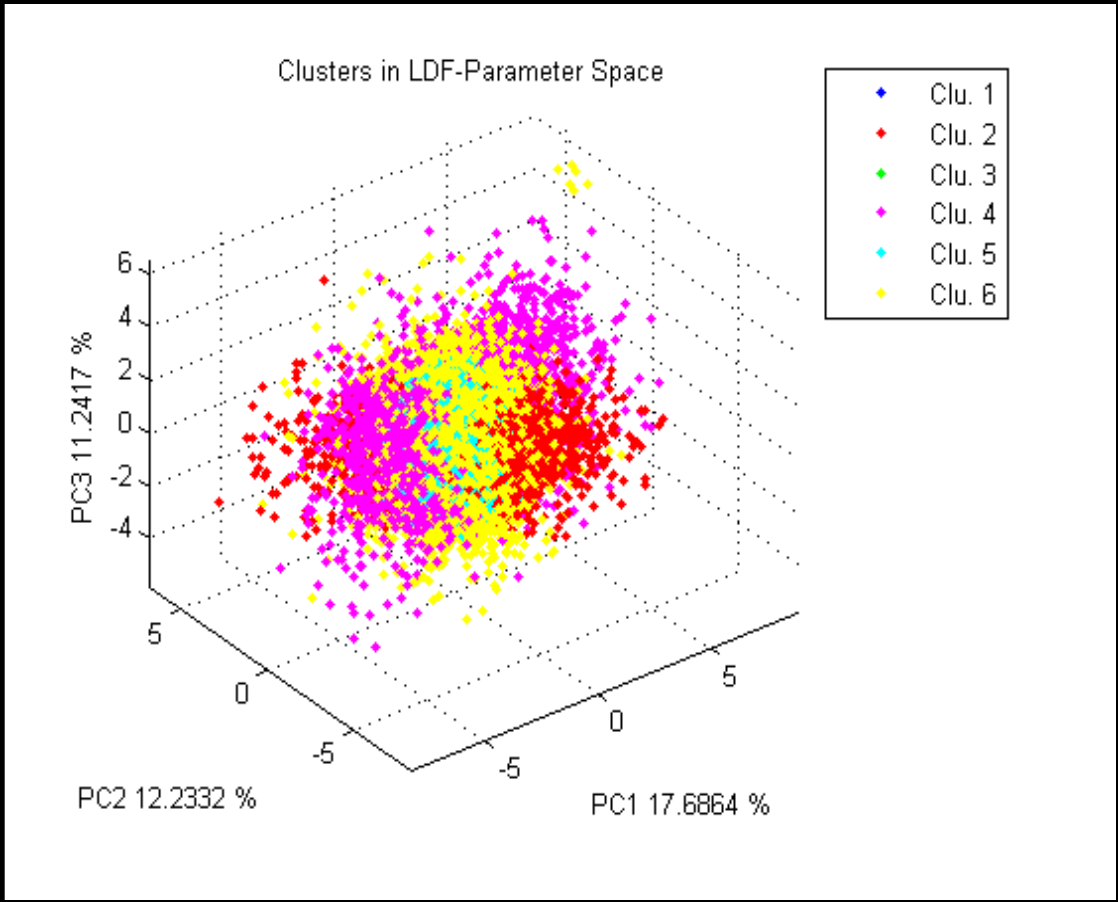




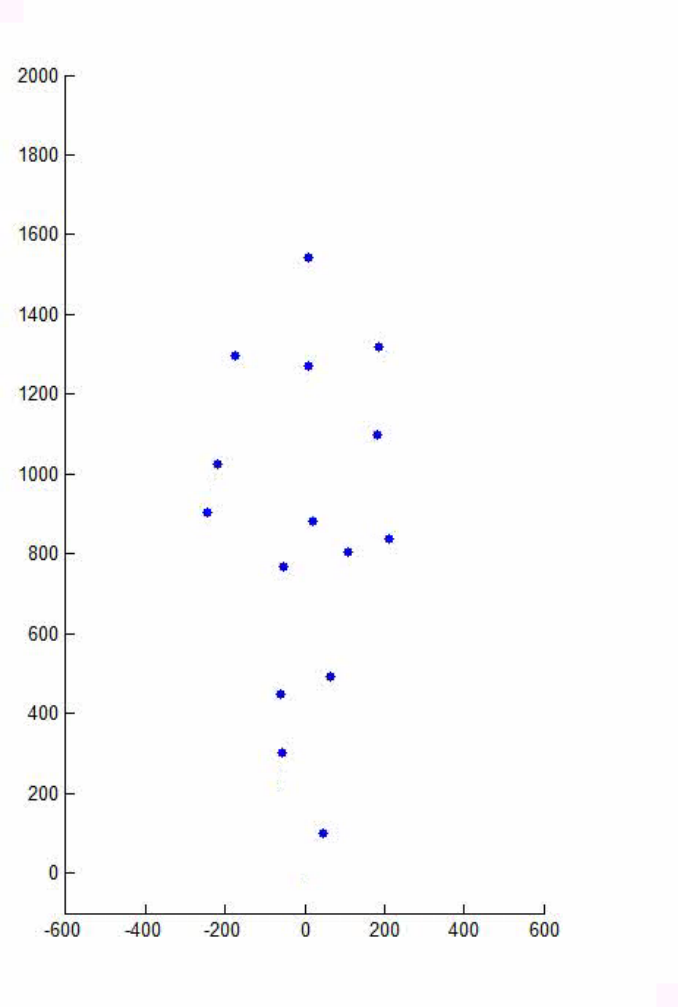
Entire attribute set

~40,000 entries

- Low-dimensional representation of clusters
- Algorithm converged on multiple clusters of ambiguous characteristics



Cluster 2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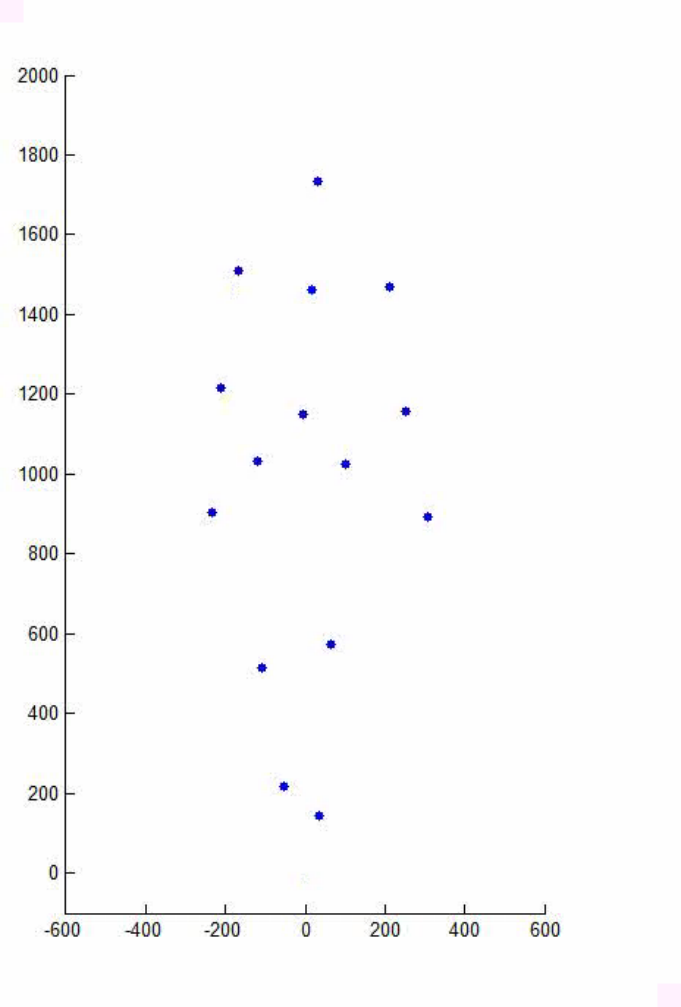
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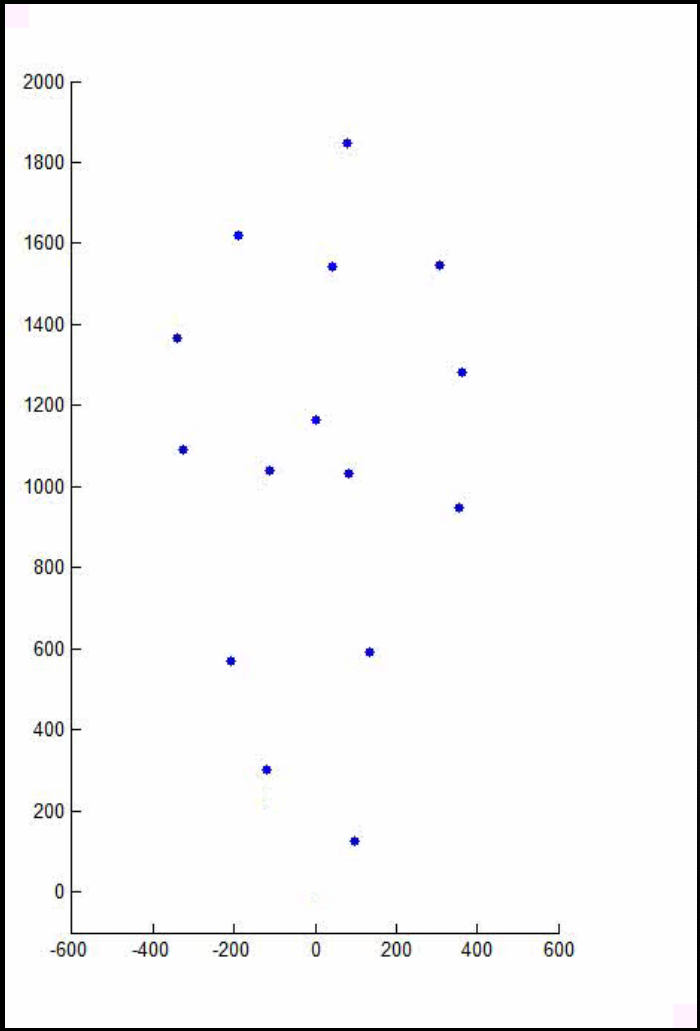
Cluster 4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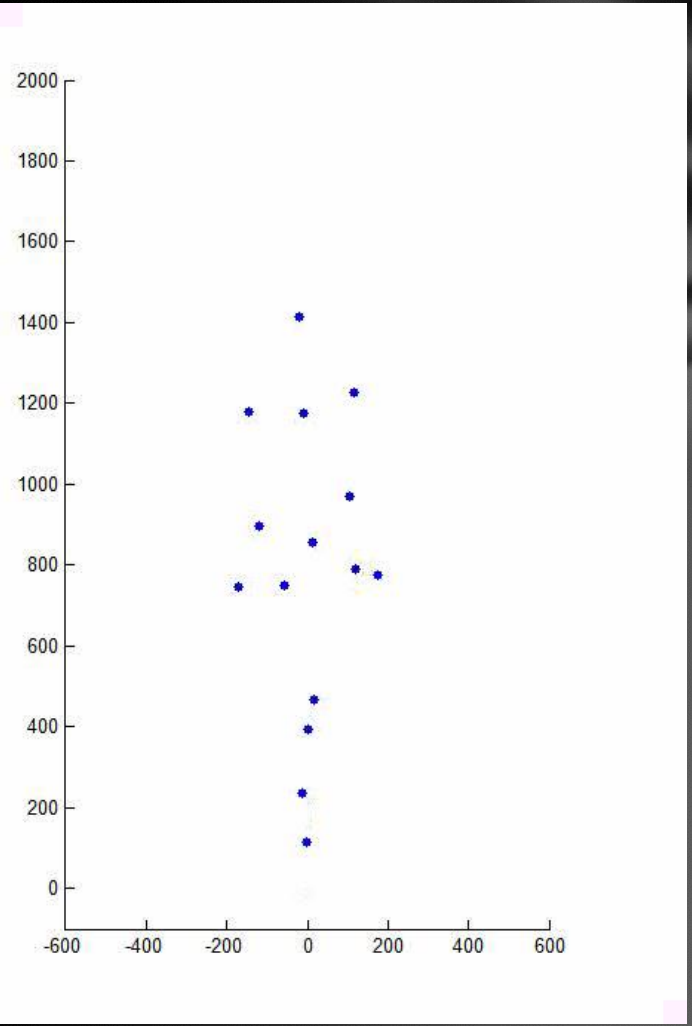
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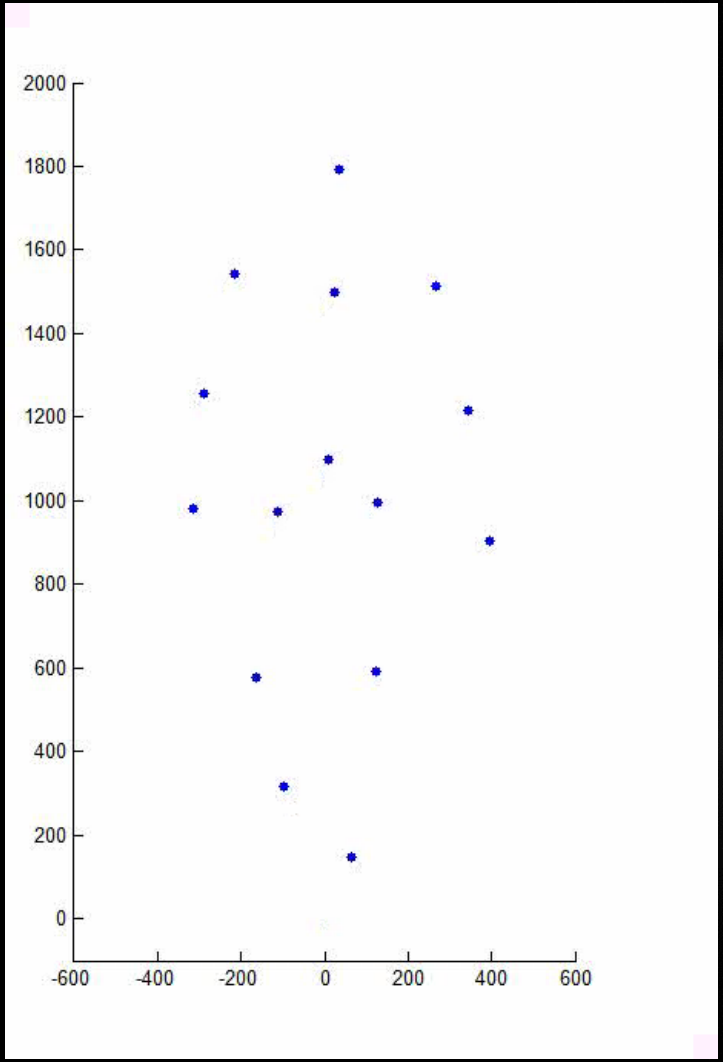
Cluster 6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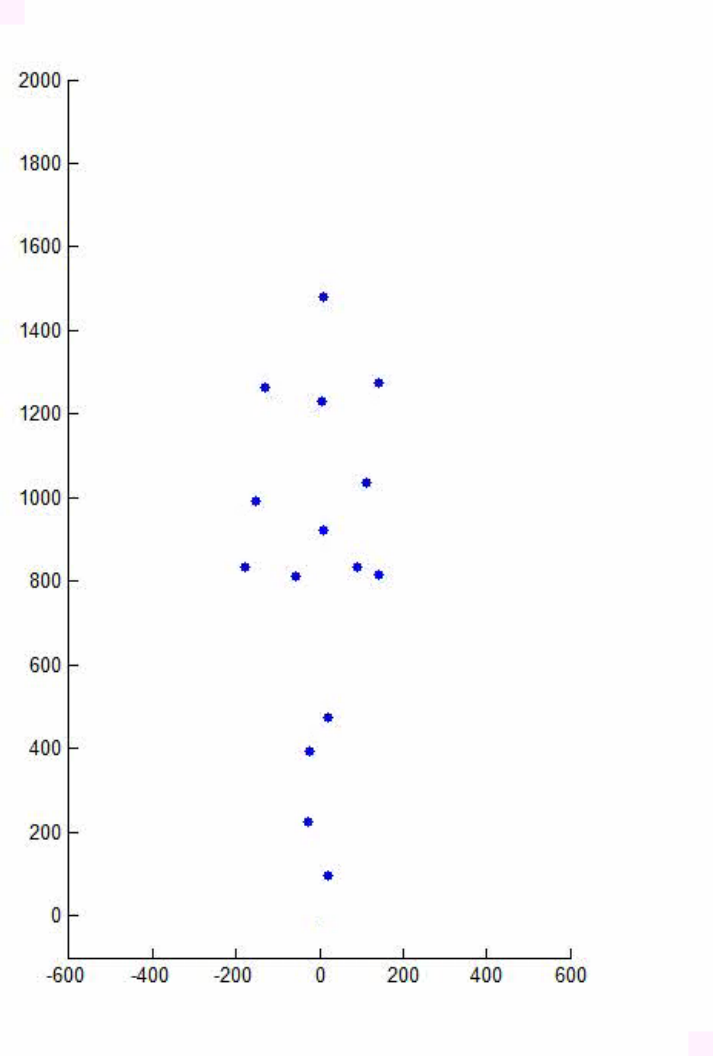
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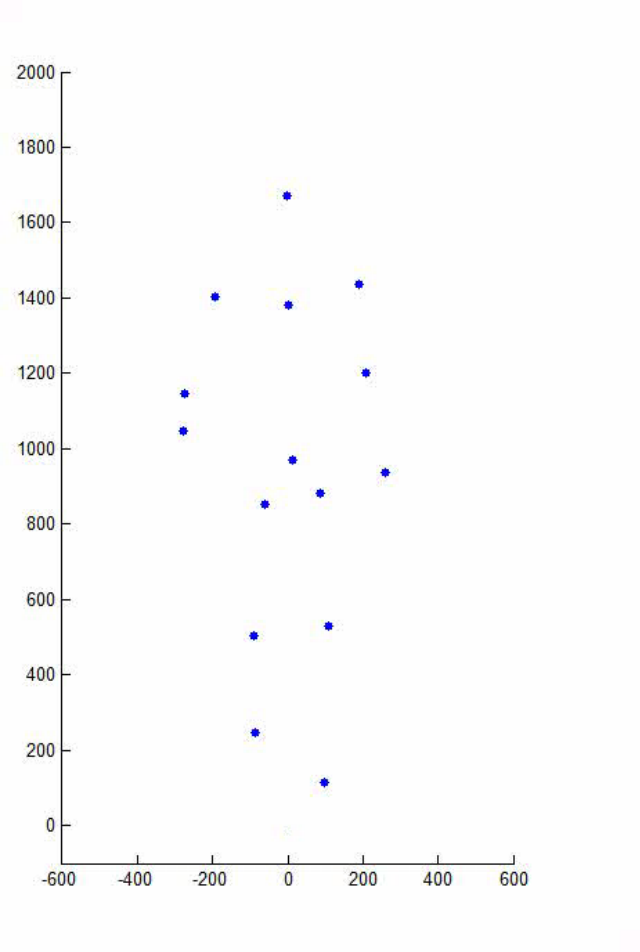
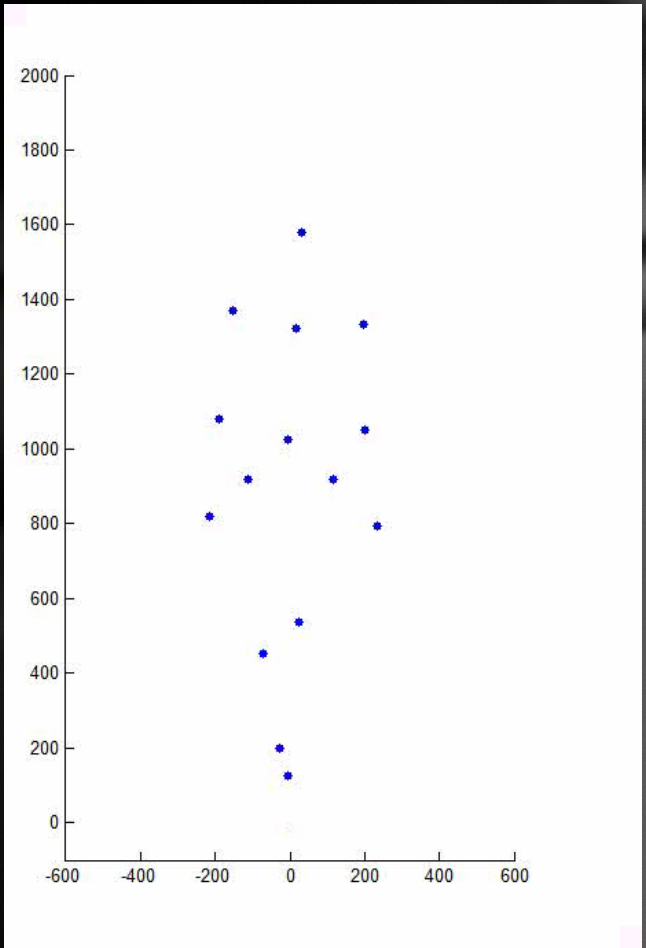
Sexiness!

Three different clusters came out of perceived sexy (or unsexy) people

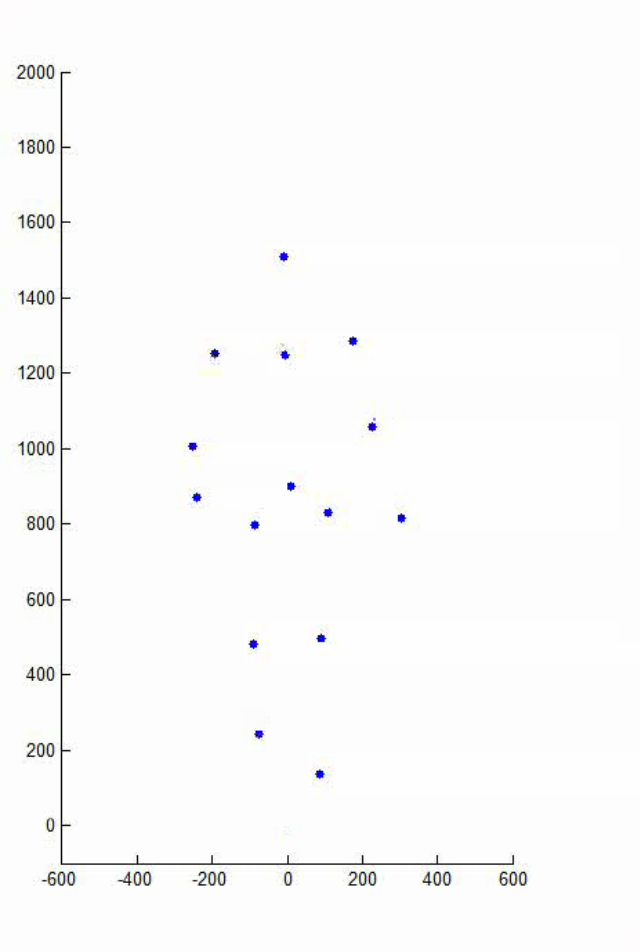
- Vigor
- Sexiness (male)
- Sexiness (female)

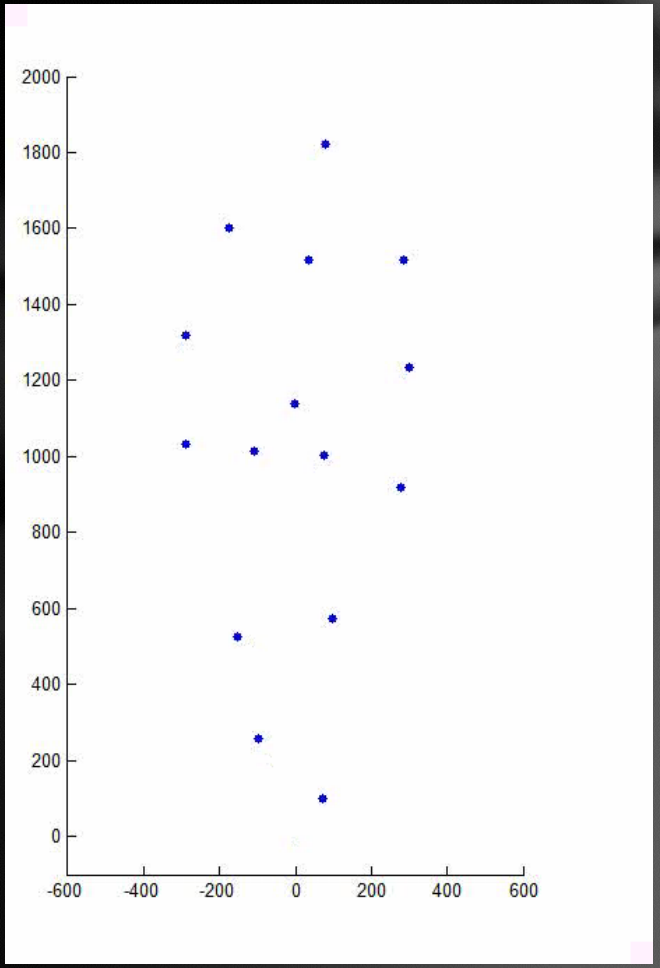
‘Vigor’ cluster



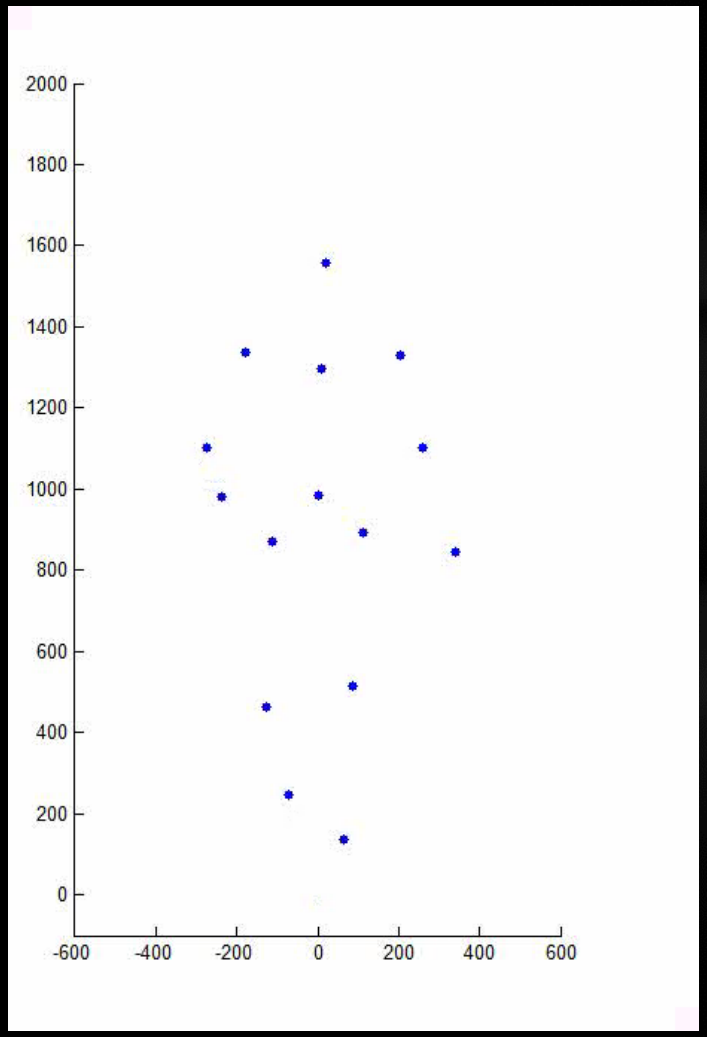


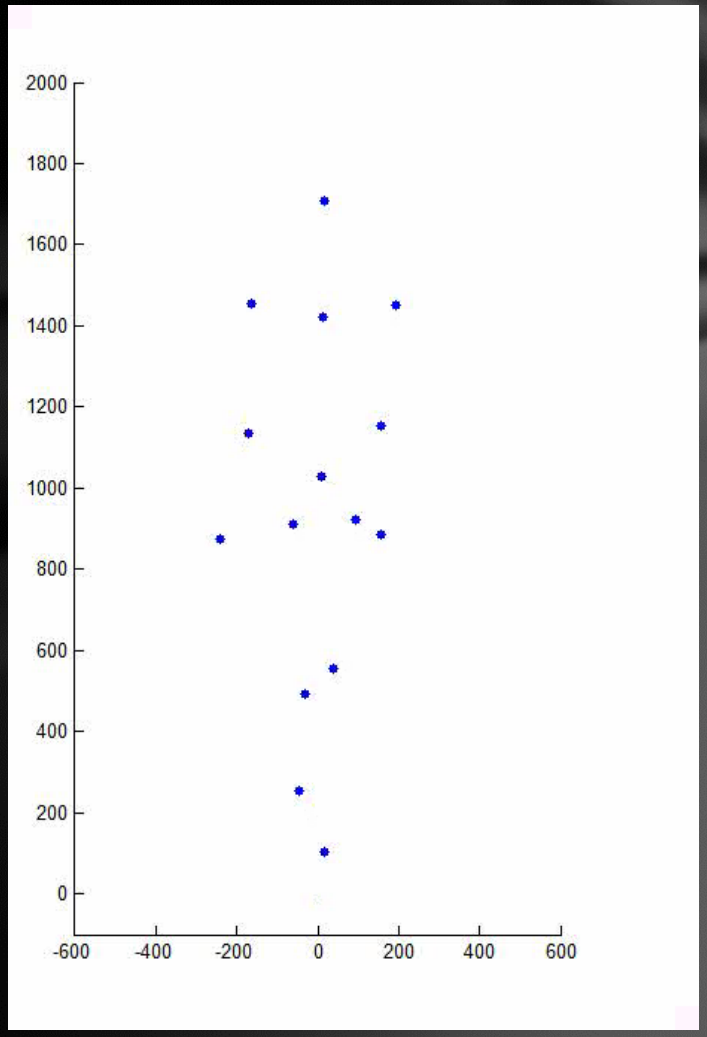
Sexy cluster (Male)





Sexy cluster (Female)





Summary

Dynamics of biological motion represented by Fourier coefficients

Walkers represented by low-dimensional eigenWalkers

Attribute-specific 10-D Linear Discriminant Functions

Do these LDF parameters of many attributes cluster? i.e. Is there some lower-dimensional human perception space to represent various style attributes?

Seems to be the case

Future Work

- Additional filtering criteria
  - E.g., Remove random rating responses or scales.
- Clustering alternatives
- Quantification of distance between clusters

Thanks for your attention!

Questions?

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