Principal Component Analysis

EDP 619 Week 10

Dr. Abhik Roy

Survey Research Methods

Welcome!

There are a lot of things going on behind the scenes when using PCAs and this is just a very brief introduction without any audio. I have tried to minimize the jargon and complexity, though some items may not be as clear as others. If you have questions, please feel free to reach out.

Additionally you may notice the following icons in the footnotes. These contain links to external sites that provide extra materials that may be of interest to you.

HTML — Extra Content

PDF — Paper Material

Rmd — Guided Example

R Script

Online Video

Prerequisites

This slideshow assumes that you have a basic understanding of variance and correlations. For a refresher, please take a look at both reviews below

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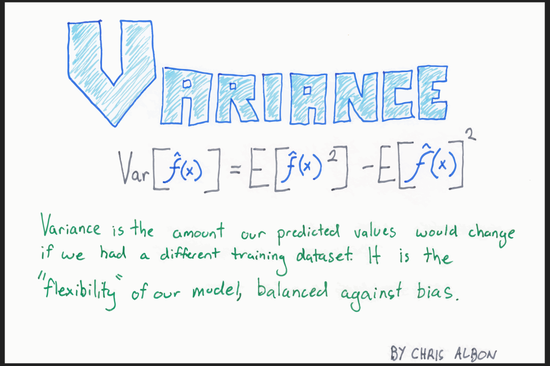
Variance is essentially a measure of the spread between points in a data set. Specifically it tells us how far each data point in a set is from the mean and by proxy from every other data point in that set.



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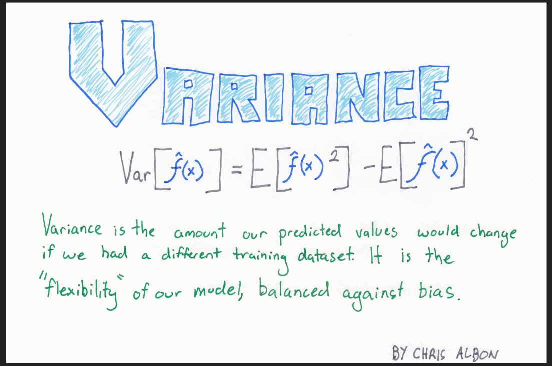
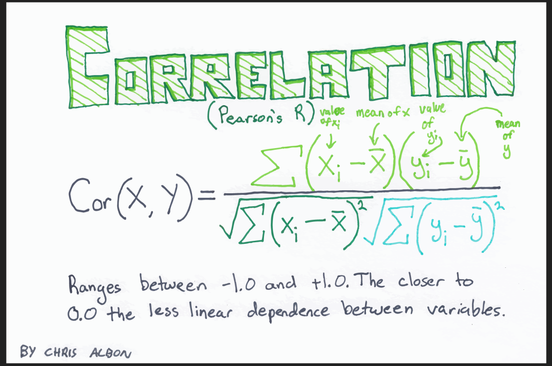


Correlation gives you an idea of the strength or weakness of the relationship between two variables. In a survey where each item is set to measure a single construct, these are essentially the applicable questions.



More Review

If you would like a deeper dive on either area, tale a look at the videos below

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Variance

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Variance

Correlation

From Basic to Better

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...enter a method called ***Principle Component Analysis***

Principle Component Analysis (PCA)

Steps in a Nutshell

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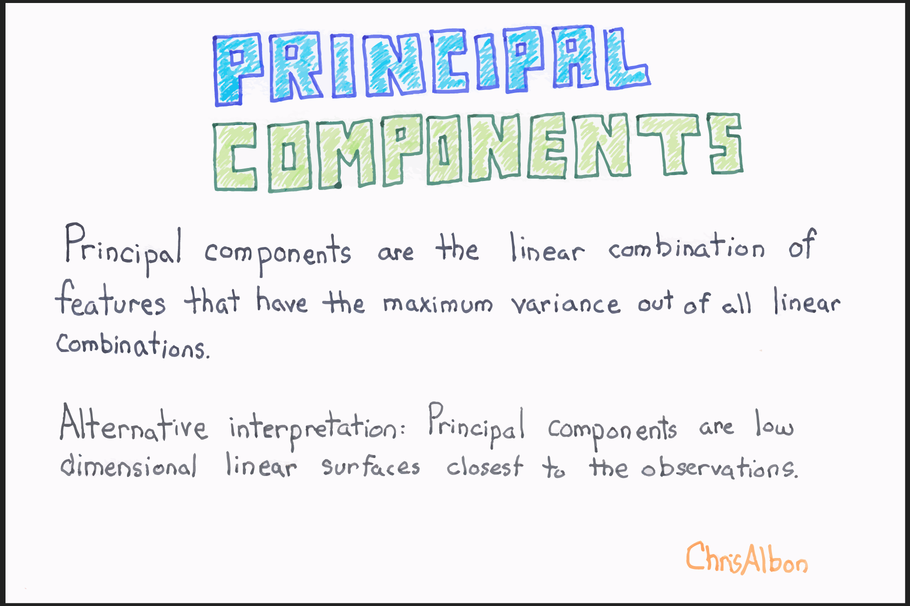
Locate the directions, or *components*, in a data set with high variance



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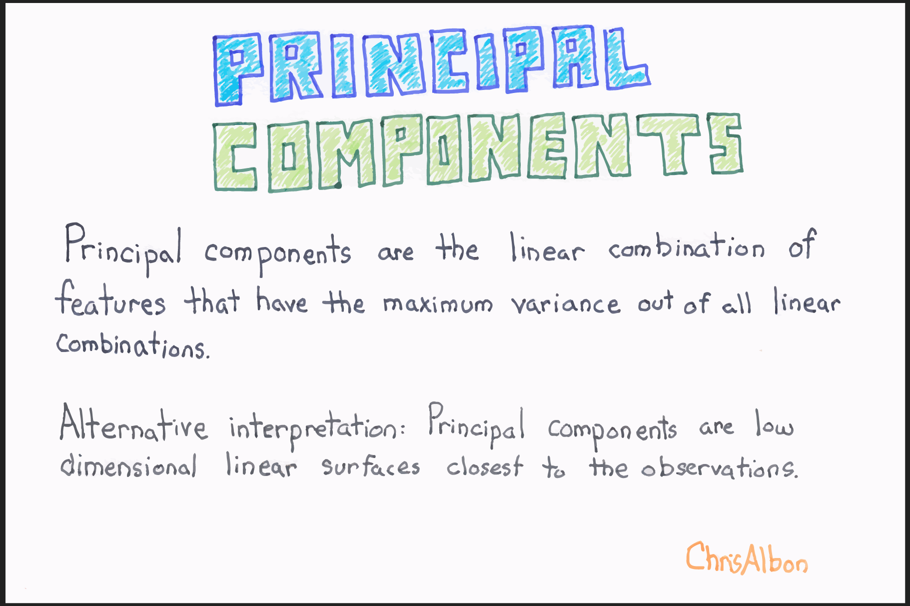
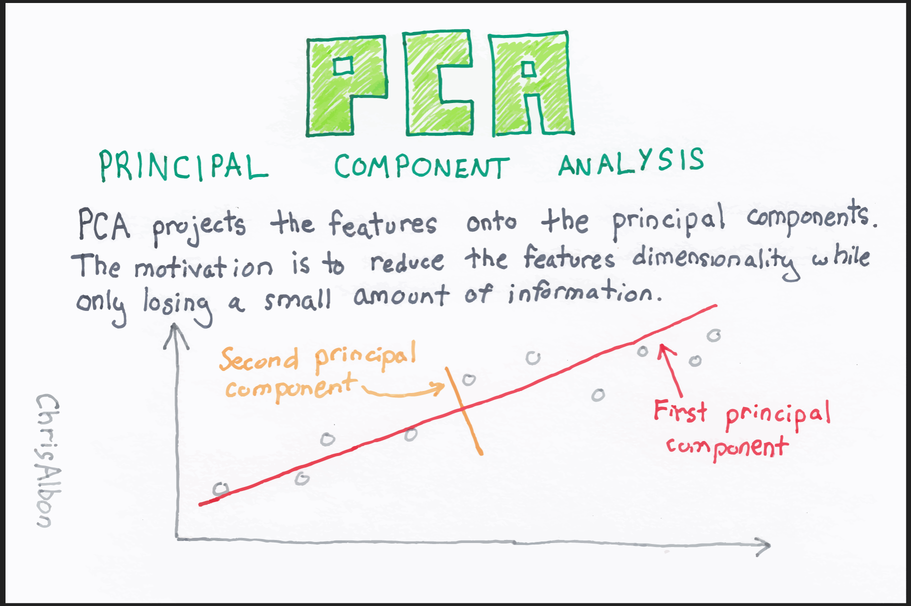


Find a limited number of components with high variance that in aggregate can explain most of the overall variance in the data



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Dimensionality - The number of input variables, or *features* in a dataset. In a spreadsheet, you can think of these as the column names.

id	read	write	math	science	socst
70	57	52	41	47	57
121	68	59	53	63	61
86	44	33	54	58	31
141	63	44	47	53	56
172	47	52	57	53	61
113	44	52	51	63	61
50	50	59	42	53	61
11	34	46	45	39	36
84	63	57	54	58	51
48	57	55	52	50	51
75	60	46	51	53	61
60	57	65	51	63	61
95	73	60	71	61	71

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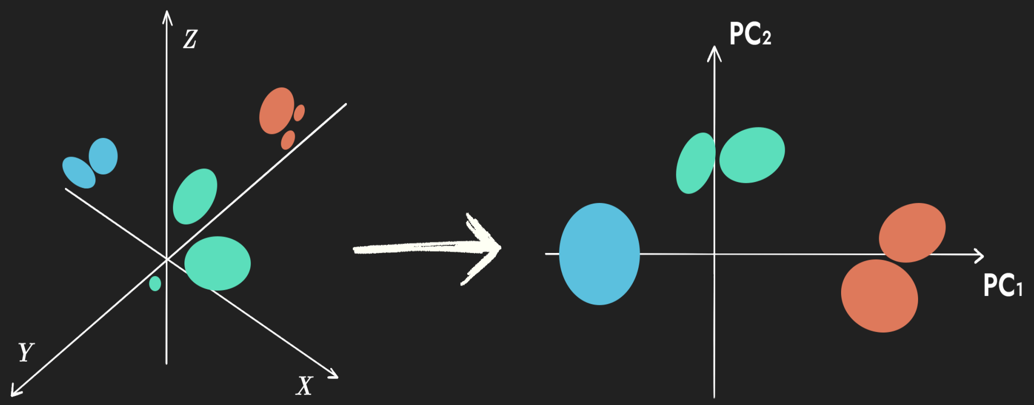
Dimensionality Reduction - Statistical techniques used to reduce the number of input variables.



The Problem with Dimensions

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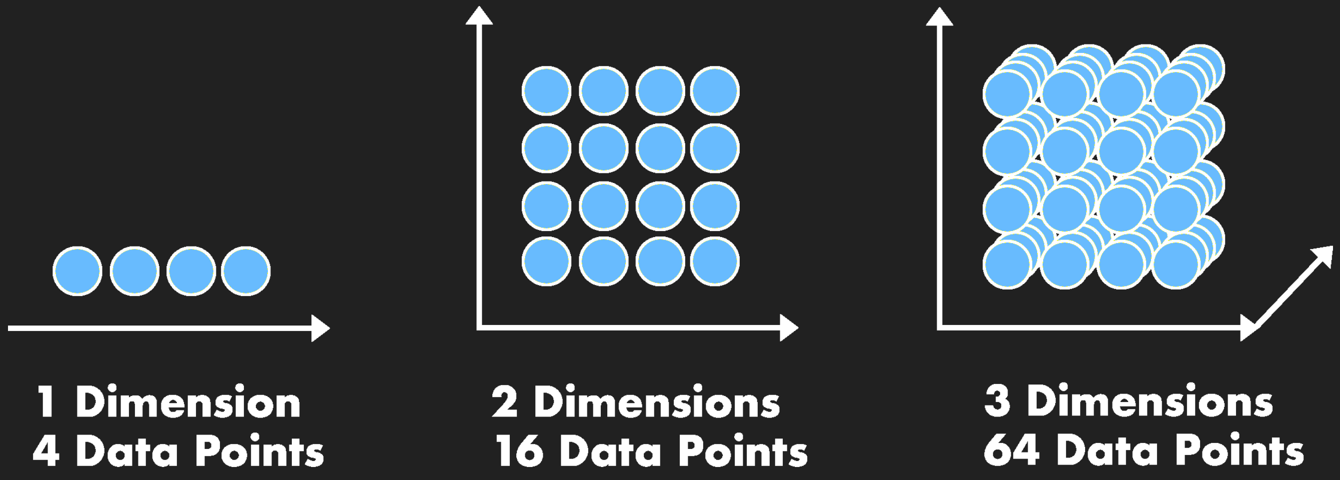

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Note as with most other procedures: *what you gain in efficiency, you lose in precision*. In a nutshell, there is no known perfect method that can both get rid of all of the noise and leave only relevant information. However with an ever growing machine learning library of approaches, we could get pretty close well within your lifetime!

How Do PCAs Work?

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How Do PCAs Work?

Before moving on please note that this is a nutshell explanation of the steps and avoids the mathematics[1]. If you are interested in a more nuanced introduction coupled with the mathematics, watch this amazing lecture by Josh Starmer from StatQuest[2].

[1] PDF [2]

OK Now Really How Do PCAs Work?

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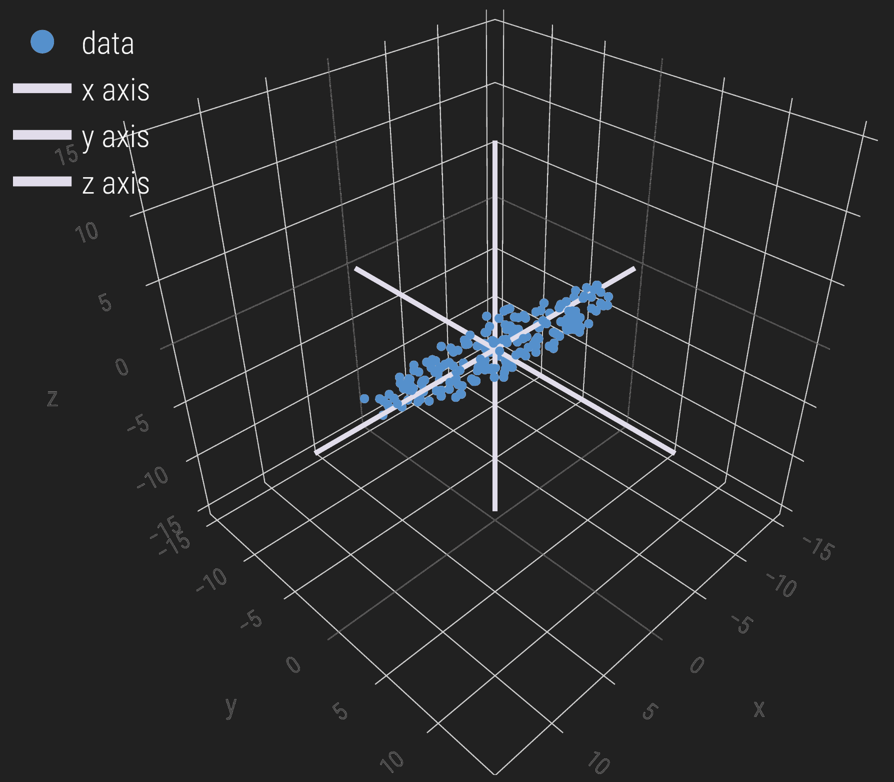
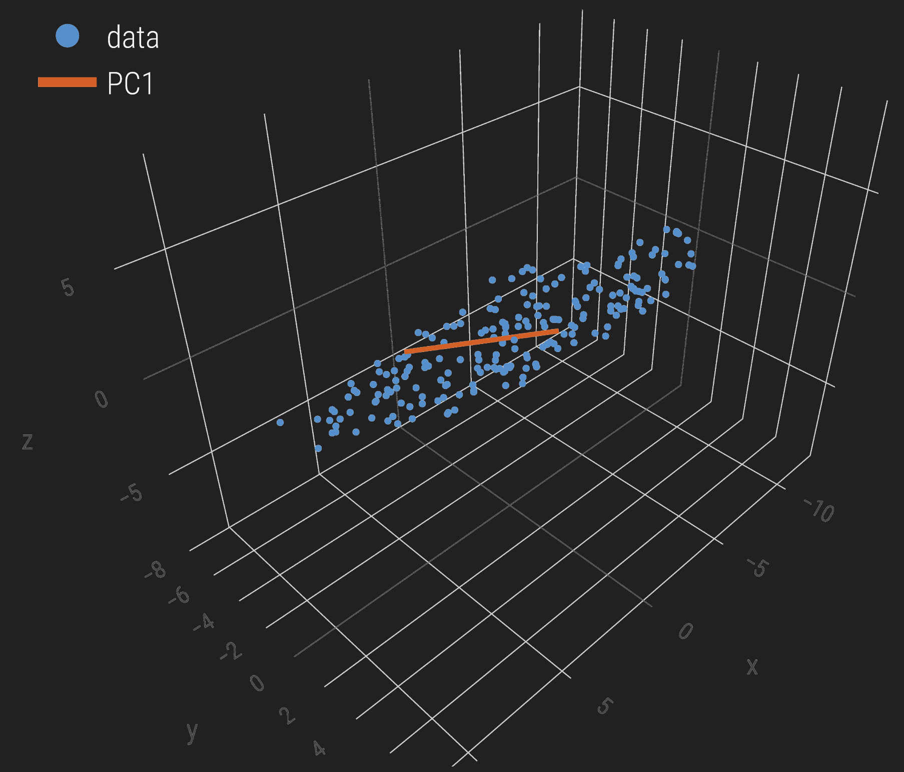
Let's look at a data set with 205 points randomly scattered in three-dimensions. Keep in mind that as you move along, the *PCA is carving out new dimensions which you will be able to see and interact with.*

When applying a PCA, it locates the...

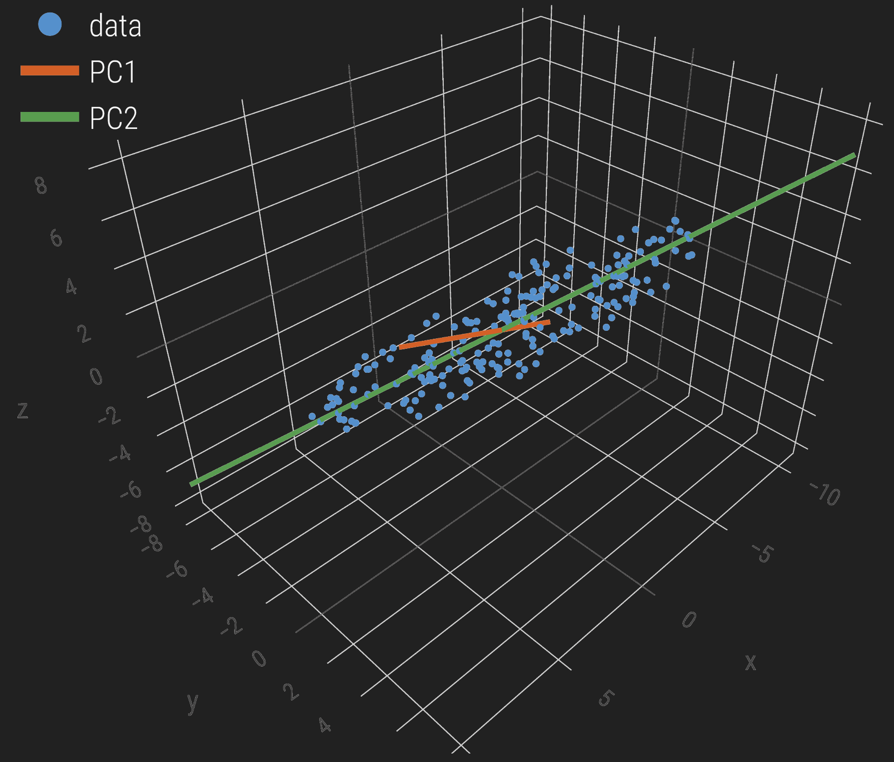
1. center point of data in multi-dimensional space



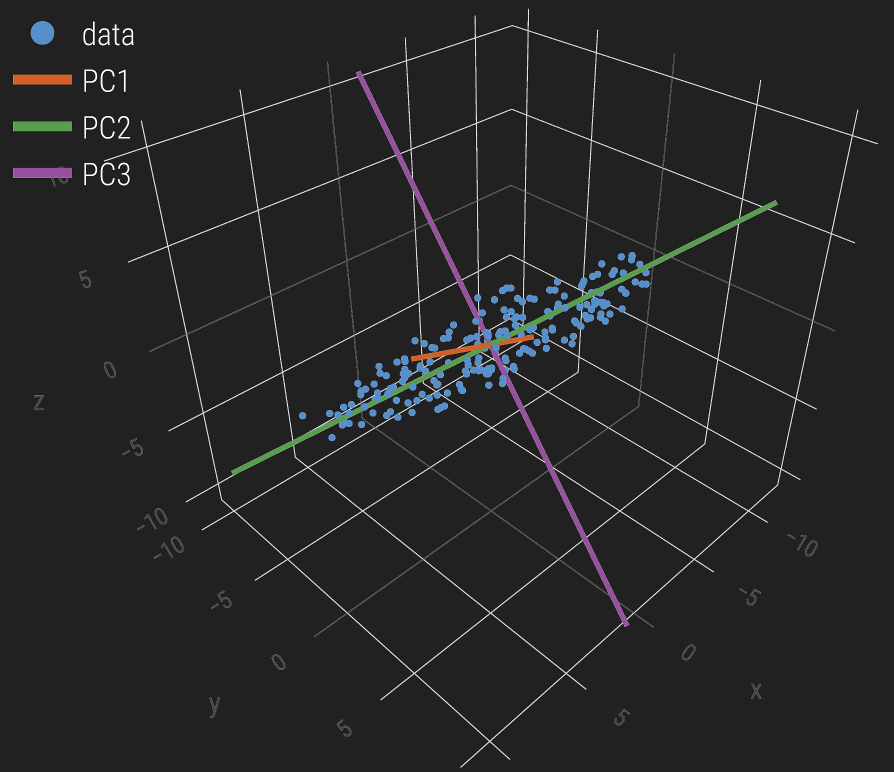
2. direction with the greatest variance. This is called the **1st component**



3. direction that is perpendicular, or *orthogonal* to the 1st component with the greatest variance. This is called the **2nd compone**



4. direction that is perpendicular, or *orthogonal* to the 1st and 2nd component with the greatest variance. This is called the **3rd component**.



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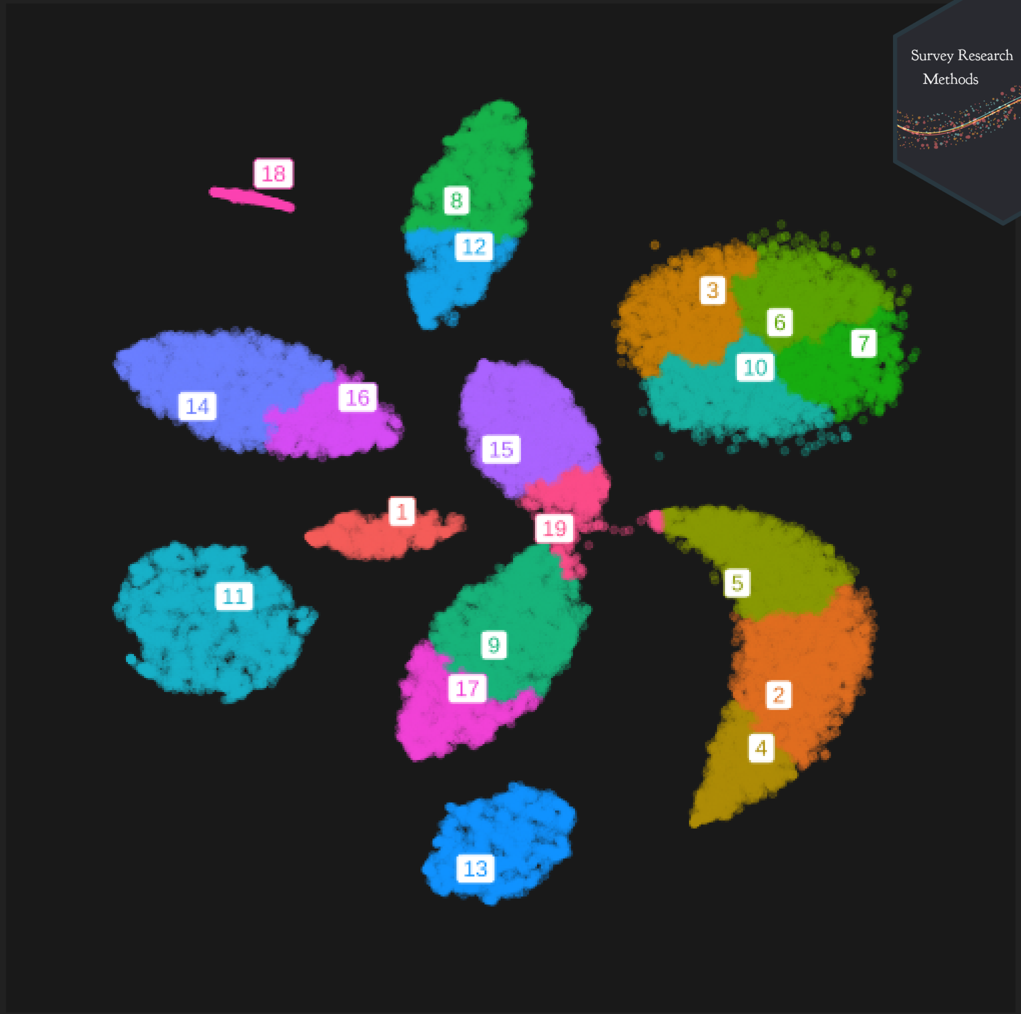
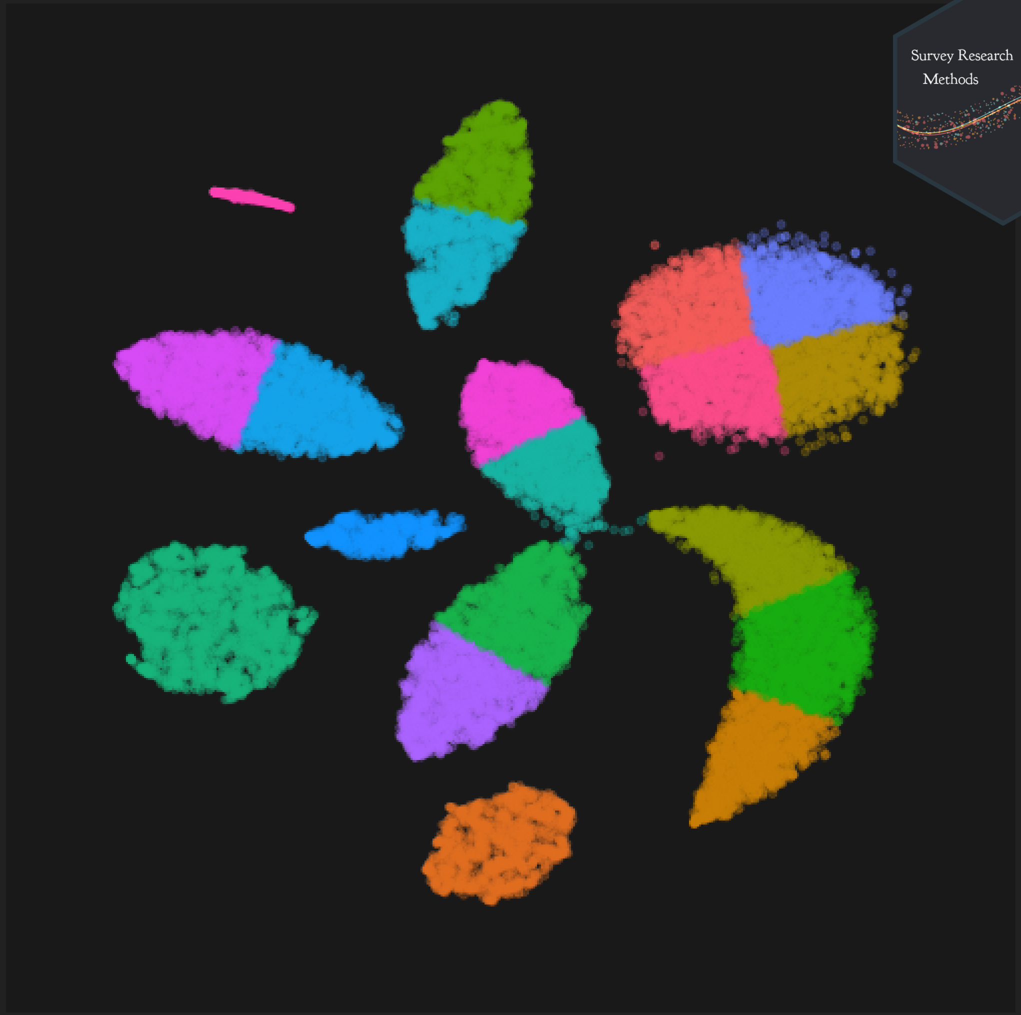
> but there are many other methods of reducing dimensions like

Hierarchical Clustering[3]



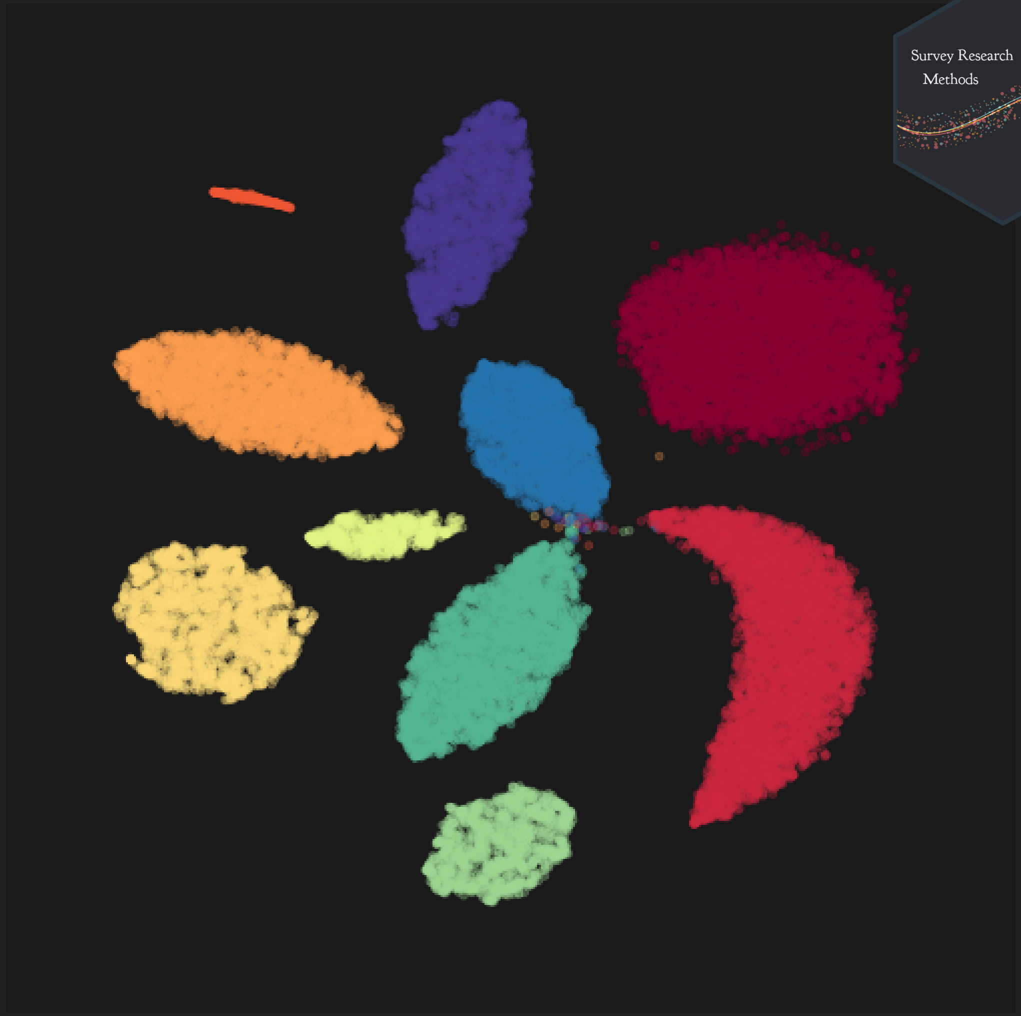
[3]

K-means Clustering[4]



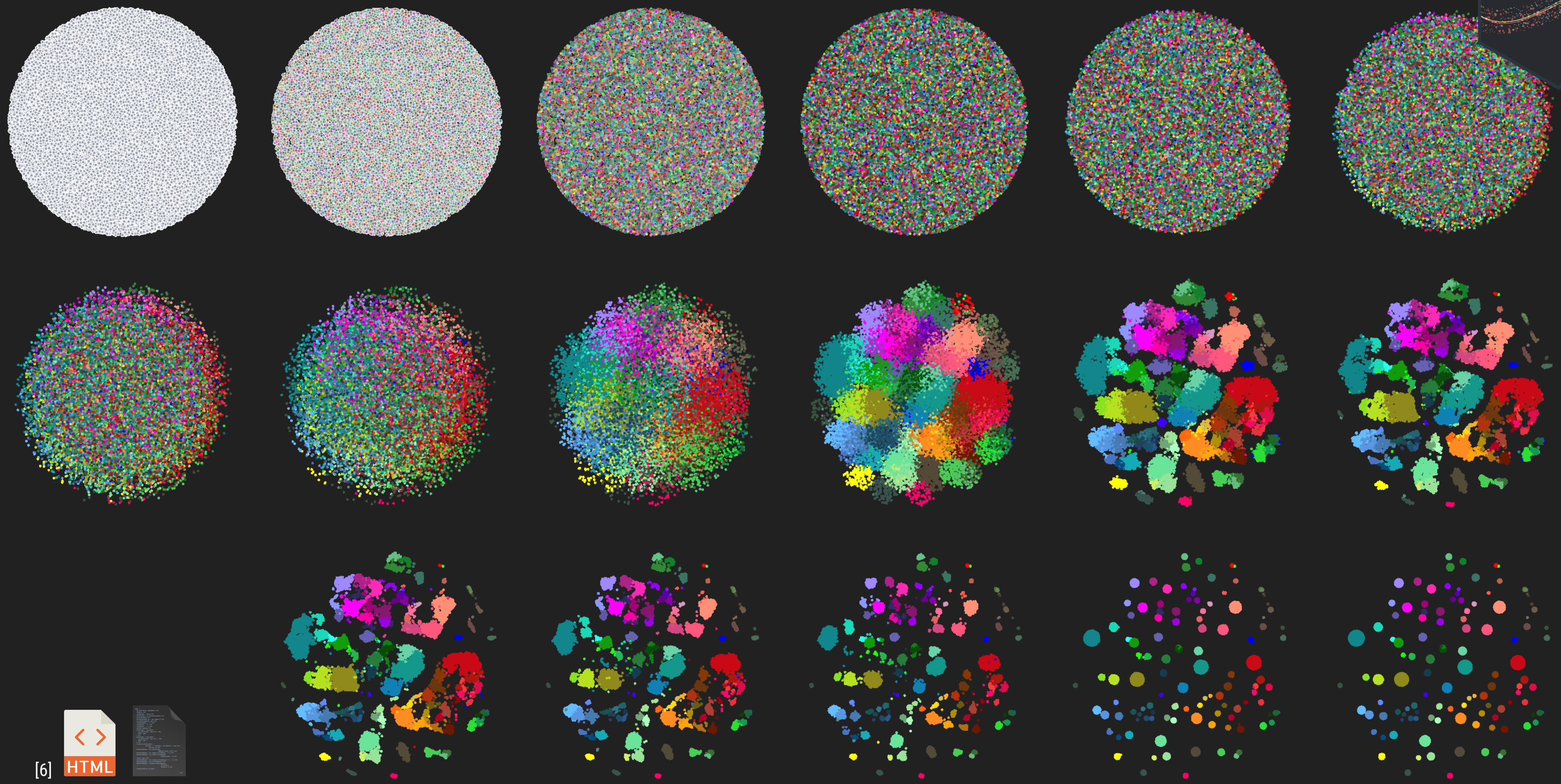
[4]

t-Distributed Stochastic Neighbor Embedding (t-SNE)[5]



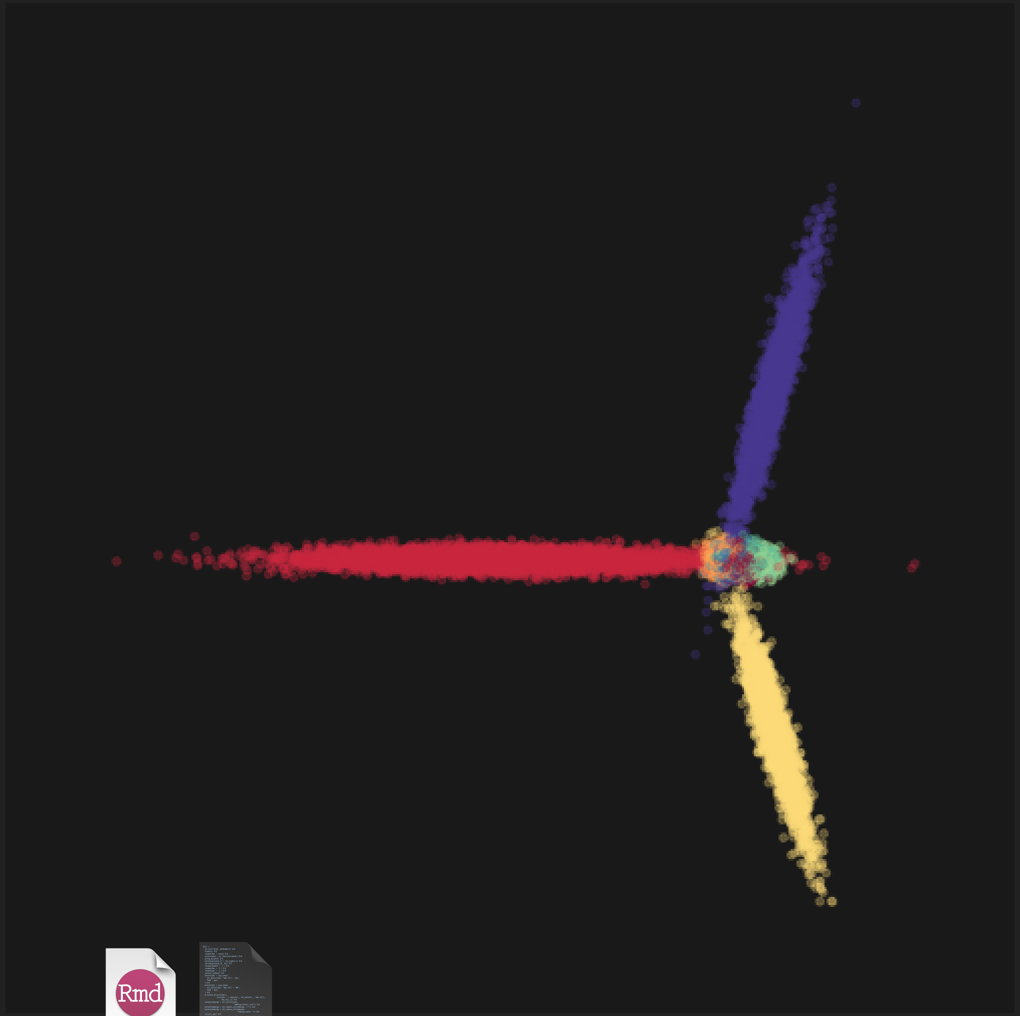
[5]

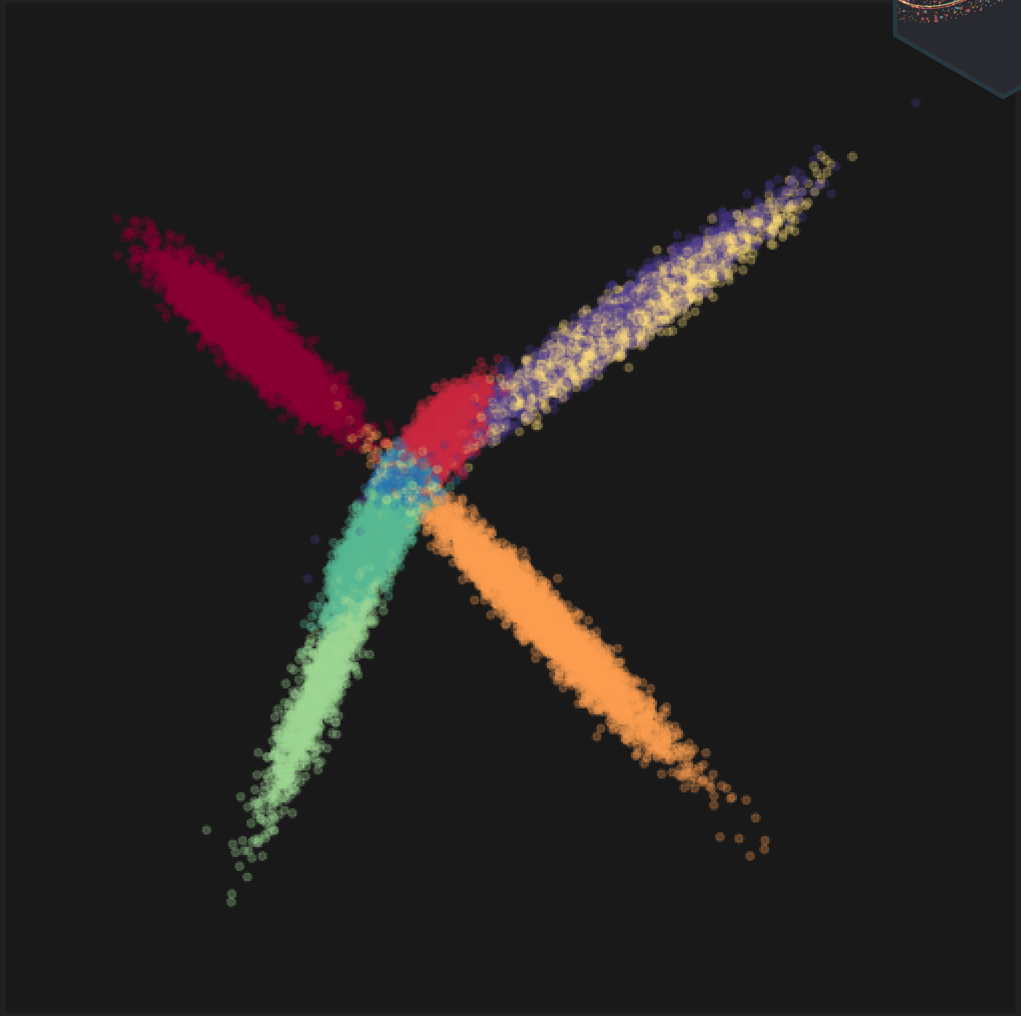
Below are steps within the the t-SNE process showing a complex data set, data reduction, and then clustering[6]



[6] HTML

And just for fun here are two pca rotations of the example data set[7]





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- how each item is similar to all others and the strength of that relationship
- which items are should likely be kept or removed

But Wait There's More!

Again this is just the tip of the iceberg. To really see the power of PCAs, take a look at machine learning. This is just one of many ways to deal with classification and dimensionality. Here are a couple resources. At this time, its good just to ignore the coding and to simply get a basic idea of each.

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