Use Cases

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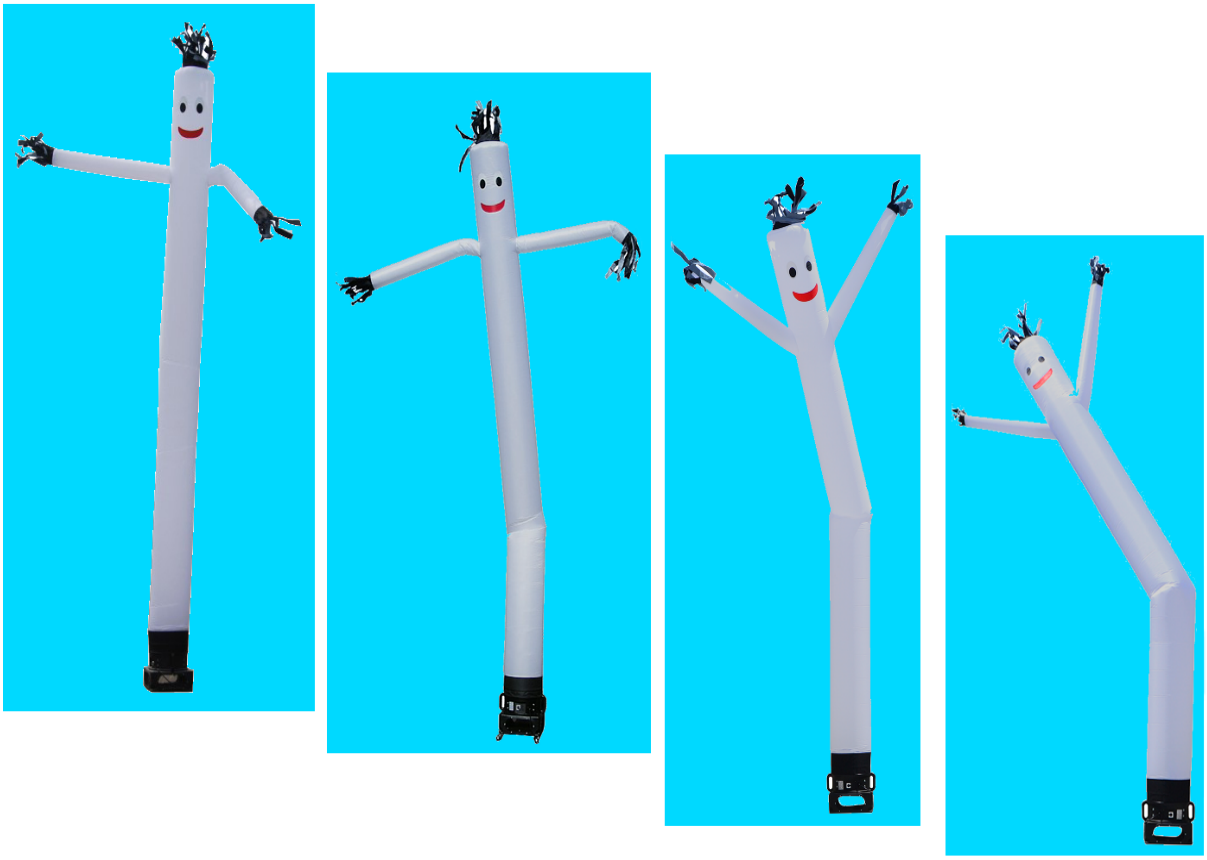
When Should I Use Isomap?

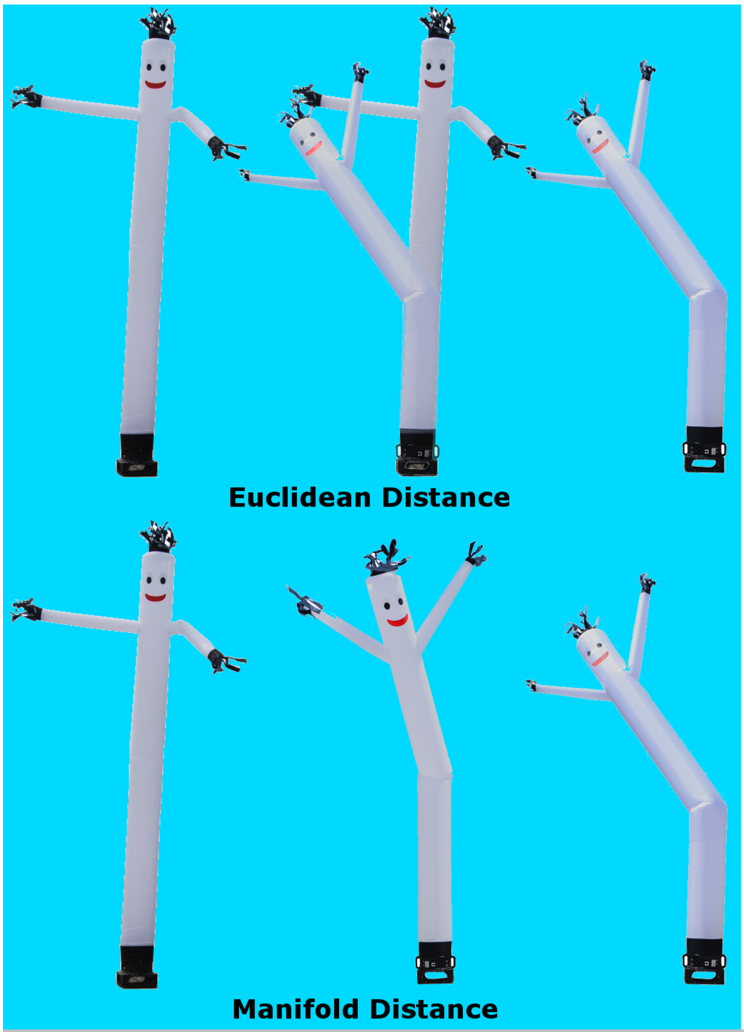
Isomap has so many real-world use cases. The most straightforward of which being whenever you believe a simpler surface can describe and preserve the inherent structure of your higher dimensionality dataset, and want to retrieve that simpler embedding.

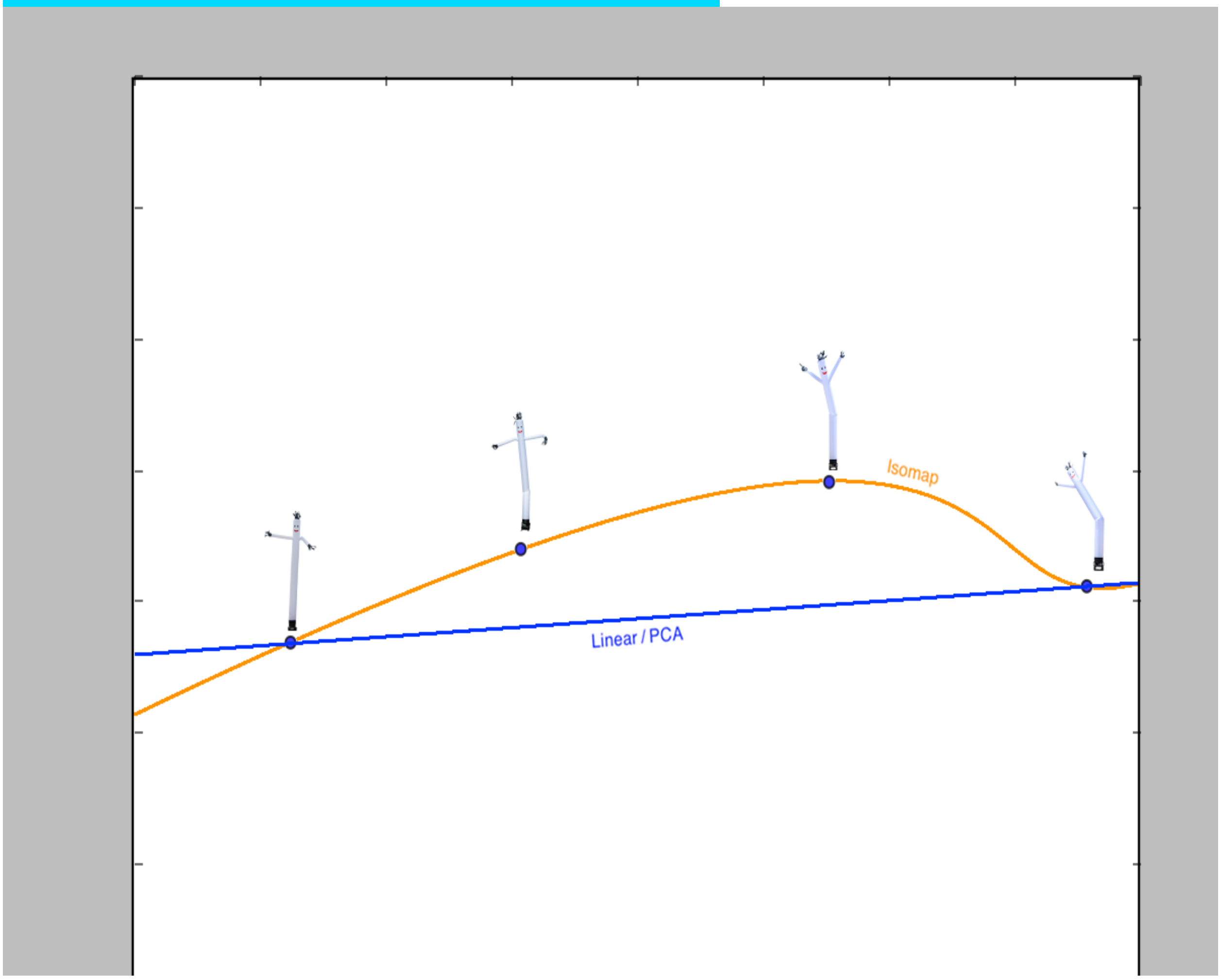
Isomap is better than linear methods when dealing with almost all types of real image and motion tracking. Recalling the expensive office chair example from earlier, either rotating the chair, having the camera zoom into the chair, or panning around the chair, etc. are all examples of very natural, non-linear motions we undertake often. If you're dataset comes from images captured in a natural way, or your data is characterized by similar types of motions, consider using isomap. Simply translating the camera up and down, or striding it left and right, are linear motions that aren't as common unless you're doing this kind of movement.

Isomap can also be better than linear methods at estimating a more accurate distance metric between different observations of your samples. Consider the following image sequence of an air dancer being deformed in the wind:



Even trained against the full set of images (plus any intermediary images), a linear model would calculate the distance between the first and last pictures using a straight-line, high dimensionality, Euclidean metric. This of course doesn't take into account the manifold's geometry. Isomap would do a better job by traversing the nearest neighborhood map:


Euclidean Distance
Manifold Distance


Isomap
Linear / PCA

Another example of this would be trying to get from one spot on a sphere to another; the Euclidean distance would be the shortest path connecting the two locations, namely, a straight line. The manifold path on the other hand, would do a much better job sticking to the surface of the sphere, based on how far apart the neighborhood sampling is. *Note: In the above graph, the orange isomap plot as been interpolated; a more accurate representation would be polyline segments connecting the four points in order.*

So long as the underlying relationship is non-linear, another area isomap tends excel at is the grouping and identifying of similar variations in similar data samples. Due to this, it is extremely useful as a preprocessor step before conducting supervised learning tasks, such as classification or regression. Even the official example of isomap in SciKit-Learn's documentation is of it being applied to group similar variations of handwritten digits, and outperforming PCA while doing so!

73 Pepper Variations From Dr. Baumler's Garden, Courtesy Denise Thornton

Finally, isomap's benefits also include all the other reasons you would use PCA or any other dimensionality reduction technique, including visualization and data compression.