A Gaussian-Process Based Model for Perceiving Structure in Motion

Anonymous CogSci submission

Abstract

Changes in the intensity, qualities, or position of a stimulus over time can significantly affect how humans interpret its meaning. One example of this comes from Gunnar Johansson's work on point light stimuli, which revealed that ambiguous arrangements of only a few stationary dots can induce striking perceptions of unified objects when set in motion. Here, we seek to further elucidate how perceptual meaning arises from the integration of common motion cues observed both in physics and everyday life. Specifically, using the probabilistic programming system Gen, we have created a model that stochastically composes dynamic dot scenes. This Gaussian Process based model assigns a primitive motion type to each dot (Random Walk, Periodic, or Uniform Linear), and generates a directed scene graph that describes inheritance of motion from one dot to another. In this way, more complex motion is formulated via groupings of dots that share common motion features and suggest interdependent objects. We posit that the model we have constructed may mirror the cognitive processes involved in dot motion perception. To this end, we developed an automated task where dot patterns generated from our model were shown to human subjects. It was the job of our subjects to infer the motion type assigned to each dot and decide which dots belong to which groups (i.e. infer the scene graph). Human performance was compared to an ideal bayesian observer and importance resampling posteriors that are constrained on only the observation of position and motion of the dots. Overall, we propose that the Gaussian Process abstraction we have implemented enables accurate and explicit reasoning about dot motion scenes, providing a framework for explaining percepts that emerge from random dot patterns.

Keywords: motion perception; point light; inverse graphics; Gaussian process

Introduction

Physicists studying motion (e.g. Brown, Hooke) and humans in their colloquial language ("waving", "bouncing", "roving", "meandering", "speeding up", "slowing down", "staying steady") appear to be able to distinguish distinct types of motion in the physical world. CITE PAPER FROM GERSHMAN INTRO ABOUT PRIMACY OF MOTION.

However, no studies have posited the generative process that mediates our ability to categorize motion, nor whether humans can consistently reason about complex motion trajectories in terms of simpler fundamental types. As an example of this, consider a sailor's complex trajectory while walking across a moving sailboat; his or her motion is composed of the boat's forward translation, their linear walking path, the random fluctuations of the wind, and the periodic rhythm of waves. Can human observers consistently decompose a scene in this way? (If this is a good example, will make a figure illustrating the decomposition of these motion types).

A sparse set of white dots moving on a black background can create percepts of *biological motion* (e.g. humans walking or dancing, fish swimming) (?, ?). No studies have addressed how the explicit combination of primitive forms of motion can create biological motion in dot scenes.

Dots that share common vectors of motion lead to perceptual grouping (i.e. "Theory of Vector Analysis") (?, ?). In this way, common motion of a set of dots relative to its background allows the recognition of unified objects. However, it is unknown whether this method of grouping applies to all motion types or whether there are special cases where objects that share motion vectors are not perceived as groups. . Our initial evidence indicates that shared periodic motion is a stronger cue for grouping than the other two types, and that dot pairs moving with uniform linear velocity yield ambiguous grouping. Moreover, proximity of dots to each other during the stimulus is a clear grouping cue.

Generating Pointlight Stimuli with a GP-based generative model

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[1]Sample of the first footnote.
[2]Sample of the second footnote.

Table 1: Sample table title.

Error type	Example
Take smaller	63 - 44 = 21
Always borrow	96 - 42 = 34
0 - N = N	70 - 47 = 37
0 - N = 0	70 - 47 = 30

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CoGNiTiVe ScIeNcE

Figure 1: This is a figure.

Acknowledgments

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References