Title
Perception, Computation, and Categorization

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Perception, Computation, and Categorization

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The thread through these three seemingly somewhat disjoint topics is the role features and models play in perceptual categorizations. Bobick begins by proposing that perceptual categorization is useful for predicting unobserved properties of objects from their observable properties. Such properties, of course, are inferred from features derived from our sense data. Which of the infinity of possible features should we elect to construct to support these inferences? Bobick provides an answer to this question by showing how a particular model for structure in the world can drive both feature selection and categorization. Nakayama then explores one very special case of the class of models proposed by Bobick namely the proposal that objects occupy distinctly separate regions in space and time. The predictable, but unobserved property is the surface of one object that is hidden or occluded by another. Nakayama shows that the machinery supporting such inferences is located quite early in the visual pathway. Finally, Jepson focusses on how feature maps interface with models such as those required for making inferences about occlusion, thereby allowing one to assign the proper world structure to seemingly inadequate sense data. The result of this interplay between features and models is an ordering of possible categorizations of the data, which leads to a formal definition for the categorization selected as "the perception."

Natural Object Categorization and Perceptual Inference

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We present a basis for generating natural categories of objects. To provide a criteria for categorization we propose that the purpose of a categorization is to support the inference of unobserved properties of objects from the observation of perceivable properties. Because no such set of categories can be constructed in an arbitrary world, we make a claim about the structure of the world -- the Principle of Natural Modes -- and argue that a natural categorization should to reflect this structure.

We first define an evaluation function that measures how well a set of categories supports the inference goals of the observer. Entropy measures for property uncertainty and category uncertainty are combined through a free parameter that reflects the goals of the observer. Natural categorizations are shown to be those that are stable with respect to this free parameter. These categories are related to Rosch's Basic Level Categories. We next develop a categorization paradigm that utilizes the categorization evaluation function in recovering natural categories. A statistical hypothesis generation algorithm is presented that is shown to be an effective categorization procedure. Examples drawn from several natural domains are presented, including data known to be a difficult test case for numerical categorization techniques. Once a categorization has been discovered, the evaluation function can be used to measure the utility of features in recovering natural categories. Finally, we consider the extension of the paradigm to a categorization system that describes objects using a representation language richer than simple property descriptions.

Visual Inference in the Perception of Occluded Surfaces

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If a surface is hidden behind another surface, we often infer its continued existence even though it is literally invisible.

At what level of cognitive representation should we attribute such knowledge of occlusive spatial relations? Is our knowledge of occlusion represented relatively late, perhaps as a form of general spatial reasoning, or is it specifically visual and represented much earlier?

From a series of perceptual demonstrations and psychophysical experiments, we argue that the processing of occlusion is specifically visual. Such experiments show the importance of occlusion related processing in the perception of form, motion, depth and color. Furthermore, we argue that in some cases, the processing of occlusion might begin as early as primary visual cortex (area V1).

What is a Perception?

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Perception is the subject of extensive study in AI, Neurobiology and Psychology. Yet the event itself that we call a perception has never been defined formally. Here, we offer a definition hinged around how our beliefs and knowledge of the world affect the interpretation of our sense data. Given a set of beliefs, a lattice of possible belief states can be created, where the nodes in the lattice are labelled by the beliefs which remain valid or invalid. A perception can then be defined as a local maximum in a partial ordering within this lattice. Two examples illustrate how our lattice theory can represent plausible perceptual states. In one example, we also introduce the notion of a "key feature" - one capable of supporting especially strong inferences. Our "lattice theory" suggests a more meaningful, higher level state of understanding for machine systems, and also provides insight into human perception.