

Interconnected Representations for Visual Cognition

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The Problem: Human Visual Cognition is characterized by the flexibility and ease with which spatial relations and shape properties are computed. How is it possible for a system to be fast as well as being capable of computing a possibly infinite number of different spatial relations? What is the underlying computational structure? Human Visual Cognition is characterized by the flexibility and ease with which spatial relations and shape properties are computed. How is it possible for a system to be fast as well as being capable of computing a possibly infinite number of different spatial relations? What is the underlying computational structure?

Motivation: The human visual system computes qualitatively different properties with great ease. For example, topological properties like closure and containment are quite different from metric properties like reflectional symmetries and pseudo symmetries. Yet, both are computed effortlessly by the human visual system in most typical situations. There is a need for a computational framework that captures the intuition that there are qualitatively different, but interconnected levels in visual cognition. The human visual system computes qualitatively different properties with great ease. For example, topological properties like closure and containment are quite different from metric properties like reflectional symmetries and pseudo symmetries. Yet, both are computed effortlessly by the human visual system in most typical situations. There is a need for a computational framework that captures the intuition that there are qualitatively different, but interconnected levels in visual cognition.

Previous Work: Shimon Ullman has argued for a high-level, context-sensitive visual representation that he calls visual routines. In his work, no attempt was made to see if visual routines fall into qualitatively different levels. We hope to further the study of visual cognition by introducing the idea of interconnected qualitative levels and putting these different levels into a computational framework.

Approach: The form of a representation affects the ease of use in a given context. Furthermore, there are many complementary directions of processing. In particular, we have focussed on two complementary directions, namely, one in which the representational levels go from concrete to abstract and the other in which the representational levels go from abstract to concrete. All of the qualitative levels whether concrete or abstract, are high-level representations that lie beyond low-level visual representations. In our attempt to understand these representations, we focus on three topics: (a) The computational structure of the qualitative levels, (b) The interconnections between the qualitative levels, (c) The extraction of high-level, qualitative, representations from lower-level visual representations.

Impact: Understanding visual cognition is a key aspect of understanding the fluidity and creativity that characterize human intelligence. Putting visual cognition into a computational framework will help us to understand human intelligence as well as to help build more flexible artificial systems.

Future Work: Two lines of research emerge naturally from our current work. The first is to discover how the computational structures represented in the various interconnected representations are combined in a given visual context. The other is to find out how these visual representations interface with other high-level mental functions, for example, spatial representation in natural language.

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References:

[1] S.Ullman. High Level Vision. MIT Press, 1997.