Active Visualization Methods Enable Perception of Structure and Motion in Higher Dimensional Spaces

Comparing Active Vs. Passive Perception of the Rigidity of 3D and 4D Objects

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ABSTRACT
Active perception can be used to facilitate perception of the rigid motion of either 3D or 4D objects projected to a lower dimension. The perspective on 3D rotating objects can be actively adjusted to place the axis of rotation so that the 2D motion in a plane becomes invariant. For 4D objects with invariant views, the fixed axis of rotation is called the ‘invariant axis’ while the plane of rotation is termed the ‘invariant plane’.

Active and Passive Perception

Active perception involves spatial and haptic information about an object by actively interacting with the object or its visualisation on the computer screen. Passive perception, on the other hand, is concerned with the ability to discern motion primarily from the visual information without the extra information gleaned from active manipulation.

Comparison of d' values for various cases under Active and Passive Perception (When 3D)

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<tr>
<td>3D</td>
<td>1.40</td>
<td>1.41</td>
</tr>
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The Questions
Can naive subjects be trained to perceive 4D rigid transformations? If so, do active strategies help in enhancing the perception of the structure from motions of 4D objects?

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Issues in Visualization

Visualizations using the computer have gained prominence in several areas of research. Visualizations typically provide cues to highlight data of interest and to communicate information. While visualizations are powerful tools for communicating complex data, there are limitations to their effectiveness. Visualizations can be misleading if they are not designed carefully. Visualizations can also be overwhelming if they contain too much information.

The Problem for 3D Perception

Objects undergoing motion present unique challenges to the problem of object perception. An example is an object undergoing rotation. The rotation of an object in 3D space is a complex motion that cannot be easily perceived by the human eye. However, the rotation of an object in 2D space can be perceived more easily.

The Problem for 4D Perception

Objects undergoing motion in 4D space present similar challenges to the problem of object perception. An example is an object undergoing rotation in 4D space. The rotation of an object in 4D space is a complex motion that cannot be easily perceived by the human eye. However, the rotation of an object in 3D space can be perceived more easily.

The 3D Problem Extended to Perception of objects in 4D

Perceptually, the problem of extracting structure from motion of 4D objects is not unlike the corresponding problem in 3D. 3D objects undergoing rigid and non-rigid transformations, when projected into the lower 2D space, yield clearly defined motions in both cases. Thus, a naive perception of 4D objects also has the potential of revealing new insights into the perception of higher dimensional structures.

Active vs. Passive Perception

Active perception employs spatial and haptic information about an object by actively interacting with the object or its visualisation on the computer screen. Passive perception, on the other hand, is concerned with the ability to discern motion primarily from the visual information without the extra information gleaned from active manipulation.

Paradigm of Active Interaction

Rigid 3D and 4D objects undergo well defined transformations and are well understood. However, non-rigid transformations are less well understood. We hypothesize that by aligning the invariant views in 3D and 4D, the objects will be perceived better.

In 3D space, the fixed axis of rotation is called the ‘invariant axis’ while the plane of rotation is termed the ‘invariant plane’. Figures 1 and 2 illustrates the concept of invariant views in 3D and 4D.

The Results

For 3D motion, the fixed axis of rotation was called the ‘invariant axis’ while the plane of rotation for a 4D object was termed the ‘invariant plane’. The results confirm our expectation that subjects should perform reasonably well in tasks involving discriminating rigid vs. non-rigid objects.

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