Summary

The goal of the proposed research is to enable a generational leap in the techniques and scalability of motion synthesis algorithms by learning and exploiting appropriate topological representations and testing them on challenging domains of flexible, multi-object manipulation and close contact robot control and computer animation.

Traditional motion planning algorithms have struggled to cope with both the dimensionality of the state space and generalizability of solutions in such domains. This project builds on existing geometric notions of topological metrics and uses data driven methods to discover multi-scale mappings that capture key invariances – blending between symbolic, discrete and continuous latent space representations.

We will develop methods for sensing, planning and control using such representations. This project, for the first time, aims to achieve this by realizing flexibility and reconfigurability at all the three levels of sensing, representation and action generation. To this end, novel object-action representations for sensing based on manipulation manifolds will be developed and metamorphic manipulator design will be refined in a complete cycle.

The results of this project will go a long way towards providing some answers to the long standing question of the 'right' representation in sensorimotor control and provide a basis for a future generation of robotic and computer vision systems capable of real-time synthesis of motion that result in fluent interaction with their environment.

Objectives

• Development of methodology of motion synthesis that distinguishes between the topology of the object from the detailed geometry – using the former to reduce the complexity of problems solved in the latter space.

• Embedding of this methodology in several robotic systems of variable topology involving sophisticated visual sensing and state of the art manipulation systems; and develop control strategies for animated characters.

• Understanding how people solve such problems, with the goal of trying to inform representations and problem formulation, and also to suggest primitives that will be used at the lower-level control system.

• Development of methods that relate task topology with object features to end-effector/manipulator synthesis, leading to development of metamorphic end-effector/manipulator with variable topology.

• Embedding of these methodologies in state-of-the-art methods for stochastic optimal control and planning under uncertainty – aiming towards a coherent integrated planning and motion control system coupling representations on all levels of abstraction.

Work Packages

<table>
<thead>
<tr>
<th>WP</th>
<th>Object-Action Sensing and Modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP2</td>
<td>Topology Based Representation</td>
</tr>
<tr>
<td>WP3</td>
<td>End-Effector/Manipulator Design and Control</td>
</tr>
<tr>
<td>WP4a</td>
<td>Robot Motion Synthesis</td>
</tr>
<tr>
<td>WP4b</td>
<td>Computer Animation</td>
</tr>
</tbody>
</table>

Robotic Systems

- KUKA, AMTEK and DLR arms
- Schunk and iLimb hands
- Optitrack and Polhemus motion tracking systems
- KCL multfigered devices and metamorphic hands
- Bumblebee stereo system, Yorrick humanoid head, Nao humanoid robot
- Laser scanners, computing clusters...