Knot Planning from Observation
J. Takamatsu, T. Morita, N. Saga, K. Ogawara, H. Kimura, and K. Ikeuchi

Background

In Learning from Observation, only rigid objects can be effectively manipulated by a state based recognition.

Our goal is to expand the object types which the recognition can be applied. We focus on knot tying tasks. In this task, the system must be able to manipulate string-like deformable objects.

- How is a knot-state represented?
- What kinds of motion primitives are necessary for knot tying?

The knot theory answers the above two questions.

State Expression

1. Decide the starting point by selecting one of the two terminals
2. Assign numbers incrementally to each intersection
3. Assign sign to each intersection

<table>
<thead>
<tr>
<th>P-Data</th>
<th>Vertex #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Under</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Attribute</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Sign + - - + - -
Over/Under O O U U U

Motion Primitives for Knot Tying Tasks

Three types of Reidemeister Moves [Reidemeister’56]

Examples

<table>
<thead>
<tr>
<th>P_1</th>
<th>R(P_1,1) or C(P_1,1) or C(P_2,2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2</td>
<td>3 4 1 2 3 4 1 2 3 4</td>
</tr>
</tbody>
</table>

R_1(*,*) : Reidemeister Move 1
C(*,*) : Cross

T. Morita et.al, “Knot Planning from Observation”, ICRA 2003