Chemistry Lab Automation via Constrained Task and Motion Planning


High Level Instruction

Written in Chemical description language (XDL)

```xml
<XDL>
  <Synthesis>
    <Hardware>
      <Component id="beaker0" type="beaker"/>
    </Hardware>
    <Reagents>
      <Reagent name="water"/>
      <Reagent name="salt"/>
    </Reagents>
    <Procedure>
      <Add vessel="beaker0" reagent="salt" amount="10 g"/>
      <Repeat>
        <Add vessel="beaker0" reagent="water" amount="10 g"/>
        <Stir vessel="beaker0"/>
        <Monitor target="beaker0" quantity="turbidity">
      </Repeat>
    </Procedure>
  </Synthesis>
</XDL>
```

Task and Motion Planning

PDDLStream
Constrained Motion Planner

PDDL Task Planner

Automated Experiment

Chemistry Lab Skills

Stirring
Heating
Pouring

Pouring Skill

Liquid
Solid

Perception

Detect object positions using AprilTag

Solubility Measurement

Initial state
Grasp solute
Pour solute
Grasp solvent
Undissolved solute

Dissolved solute

Observe & stir
Pour solvent

Computer Vision for Solution

<table>
<thead>
<tr>
<th>Material</th>
<th>Measured Solubility*</th>
<th>Literature Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt</td>
<td>33.2</td>
<td>35.8</td>
</tr>
<tr>
<td>Sugar</td>
<td>226.8</td>
<td>203.9</td>
</tr>
<tr>
<td>Alum</td>
<td>10.0</td>
<td>11.4</td>
</tr>
</tbody>
</table>

*Solubility per 100 g of water

Project Website

https://ac-rad.github.io/robot-chemist-tamp/

arXiv
https://arxiv.org/abs/2212.09672