CS365: Artificial Intelligence

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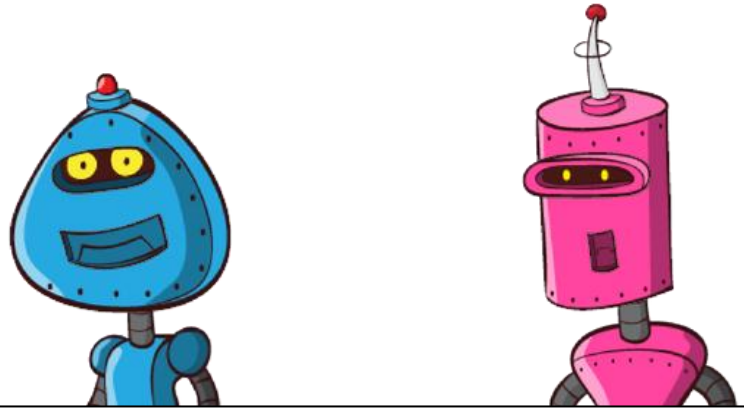
Instructional Suite for motion planning of articulated Robots with multiple links and polygonal obstacles



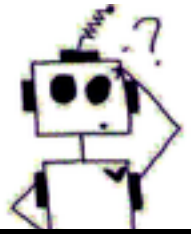
Lalit Kumar 10368 Rajiv Krishna Omar

Articulated robots are used in hazardous places where humans cannot work

- Maintenance of cooling pipes in a nuclear plant
- Point to point welding in car assembly
- Cleaning of airplane fuse lages.

Ref: Probabilistic roadmap for path planning High- Dimensional Configuration Spaces by Lydia E. Kavraki, Petr Svetka

- Plant hot cells light interventions with a long reach manipulator (Industries)
- Inspection or light intervention in hazardous environment (limited access as blind hot cells in nuclear fission industry)



Ref: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5624425&tag=1

WHY THE PROBLEM IS IMPORTANT?

how this work relates to earlier work

Prior Work: Kaushik Sinha , 2002

- Probabilistic Roadmap for Path Planning in Hyper –Dimensional Configuration Space
- Probabilistic roadmap for path planning High- Dimensional Configuration Spaces by Lydia E. Kavraki, Petr Svetka 1996

Assumption : r-SCARA arm

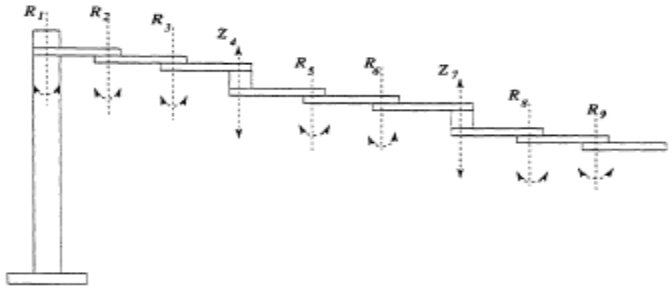
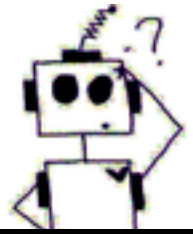
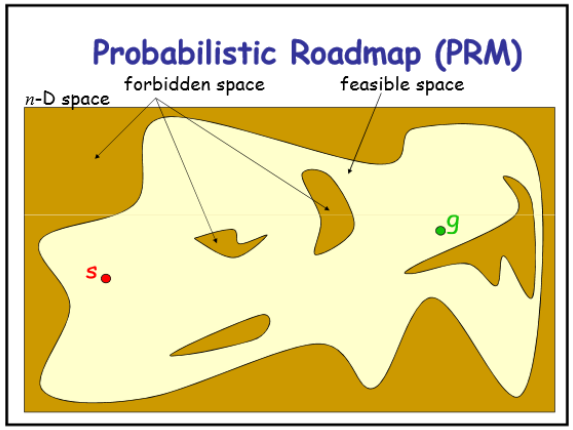


Figure 3: 7 link 9 *dof* ***r-SCARA*** arm

The basic idea –

- **Take random samples** from the **configuration space**
- Test them for whether they are in the free space
- **Use a local planner** to attempt to connect these configurations to other nearby configurations.
- The **starting and goal configurations** are added in.
- **Apply graph search** algorithm to the resulting graph to determine a path





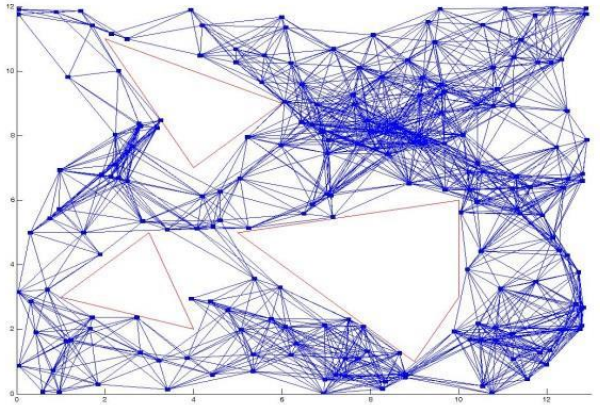


Fig. PRM Computed Graph

Algorithm/ Approach

Differences & Advantages

Methodology: We have used **PRM**

Collision detector- breaks the arms in segments also the obstacle sides in segments and then checks if the segments are intersecting.

Criteria for good solution:

- Difference of two configurations is sum of squares of non-reflex angles

Additional benefits of PRM

- angle Constraint – only a range of values is allowed for angles
- PRM handles this constraint very easily
- Just discard the node while checking for collision If angle constraint is not satisfied

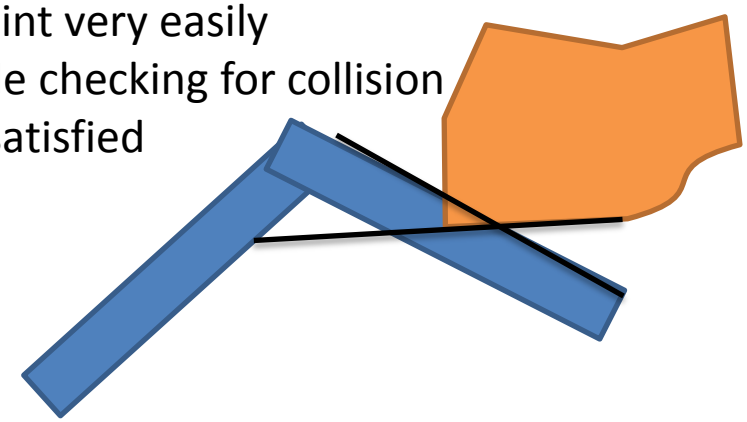
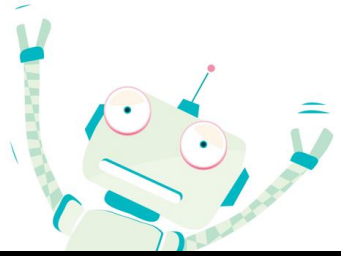


Fig. Collision Detection by breaking into segments



TOOLS From others

EL2310 Programming Assignment @ KTH

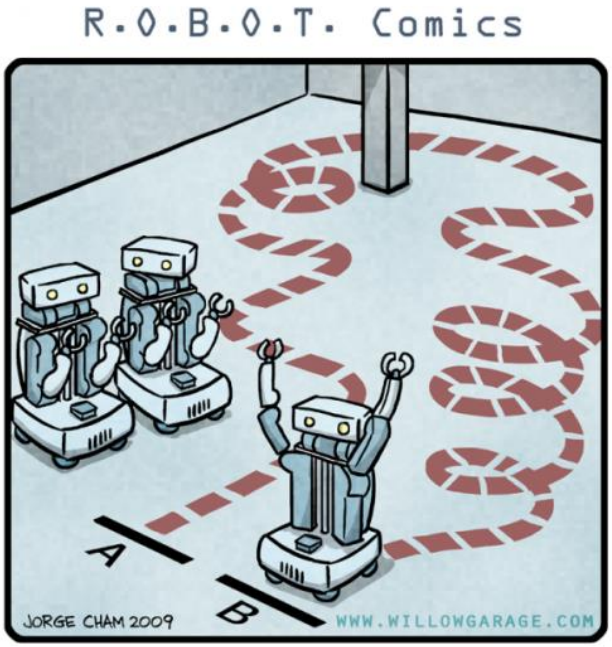
- Very basic implementation of PRM in C++

- Qt creator & Qt designer
- Qt c ++ libraries for Qt Gui and QtCore
- Qt QGraphicsScene QGraphicsView Classes and other inherited classes

DATA WE COLLECT

Data collected from GUI

- Data collected can be stored in a file
- Can be used for interactive as well as batch mode
- Can be used for isomap analysis

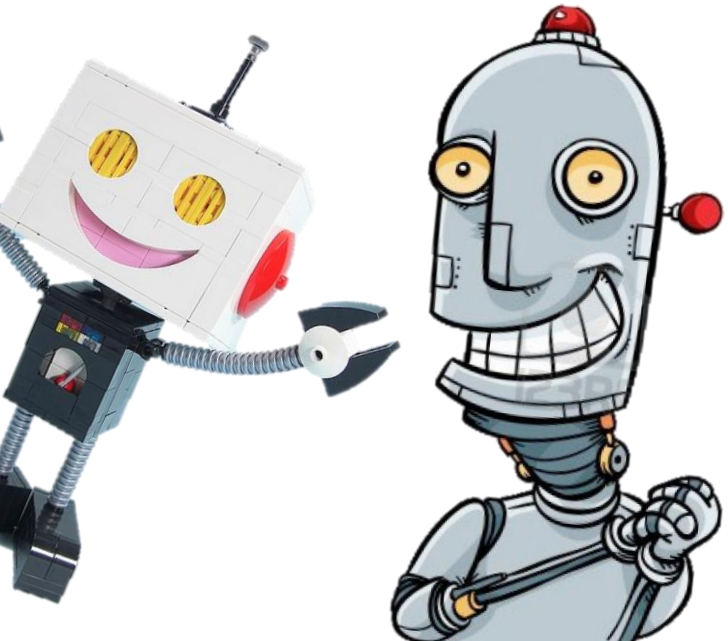


Initial and Final Configurations are not unique

- Infinitely many possible Configurations possible –Dealt by Using **Inverse Kinematics**
- N-2 Points randomly selected then solve the equation so that end point reaches start or end point.

Curse of Dimensionality

- No. of Sample points needed for approximating optimal path increases exponentially with dimensions.

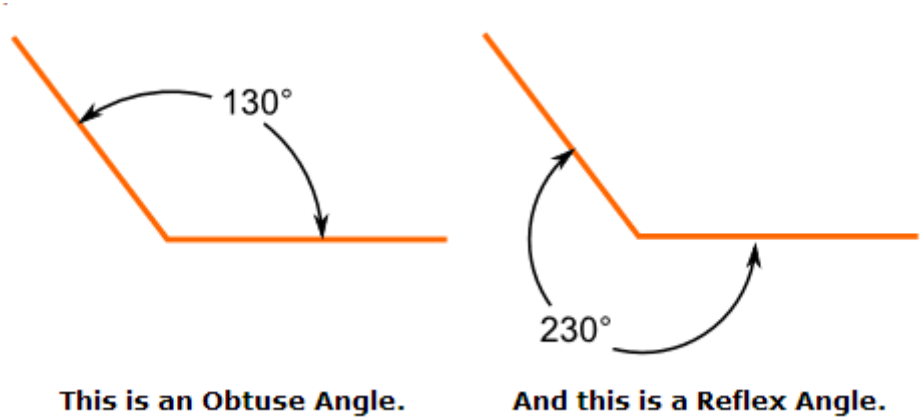


RESULTS

Distance Metric can be improved.

- Currently we use difference of two configurations is sum of squares of non-reflex angles

- Can change this metric have weights associated depending on cost of different links



Sqrt($(\Theta_1-\varphi_1)^2 + (\Theta_2-\varphi_3)^2$ - - - - - -+ $(\Theta_n-\varphi_n)^2$ **)**

Collision detector- in future we will consider the width of arms and then we will break each arm into two segments and use collision detection with both segments with each segment of the obstacle.

FUTURE CLAIMS

References

[1] Artificial Intelligence- a modern Approach 2nd Edition by Stuart J russel and Peter Norwig

[2] Principles of Robot MOTION- THEORY , Algorithms and Implimentations

[3] Probabilistic Roadmap for Path Planning in Hyper –Dimensional Configuration Space
thesis Kaushik Sinha

[4] Reach Based Synthesis of Modern Hyper Reduntant Manipulaters

[5] Probabilistic roadmap for path planning High- Dimensional Configuration Spaces by Lydia E. Kavraki, Petr Svetka

[5] http://www.csc.kth.se/~chek/teaching/EL2310/coursework/cpp_project/cpp_project.html

[6] http://ai.stanford.edu/~latombe/cs26n/2012/slides/prm-basic.pdf

References for GUI

[1] http://qt-project.org/doc/qt-4.8/qgraphicsscene.html

[2] http://www.voidrealms.com/tutorials.aspx?filter=qt