Constraint-Based Generation of Trajectories for single-Arm Robots

Mathieu Collet[1,2,3], Arnaud Gotlieb[2], Morten Mossige[1,3]

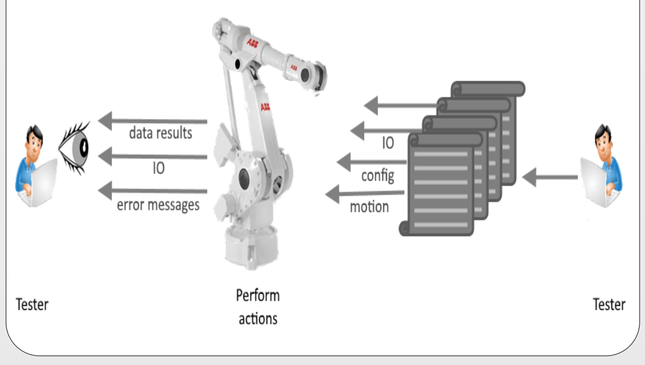
[1] University of Stavanger, 4036 Stavanger, Norway

[2] Simula Research Laboratory, Lysaker, Norway

[3] ABB Robotics, 4349 Bryne, Norway

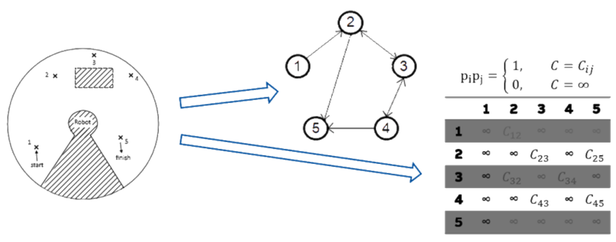
Introduction

- The software testing is an important activity during software development
- Large diversity of robot configurations
- By the using of intelligent processes (**constraint programming over continuous domains**), test cases will be automatically generated
- Include diversity between tests



CCB and RT Generation component

- Based on a **RealPaver**, a constraint solver over continuous domain
- Check the reachability between two points by checking the non-existence of intersection between the line passing by the two points and the various forbidden areas
- Build the graph of connection and the accessibility matrix between all points.



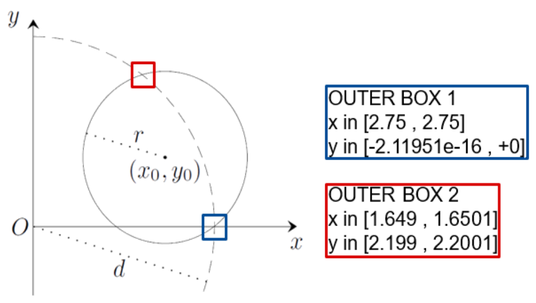
CCB and RT Generation component

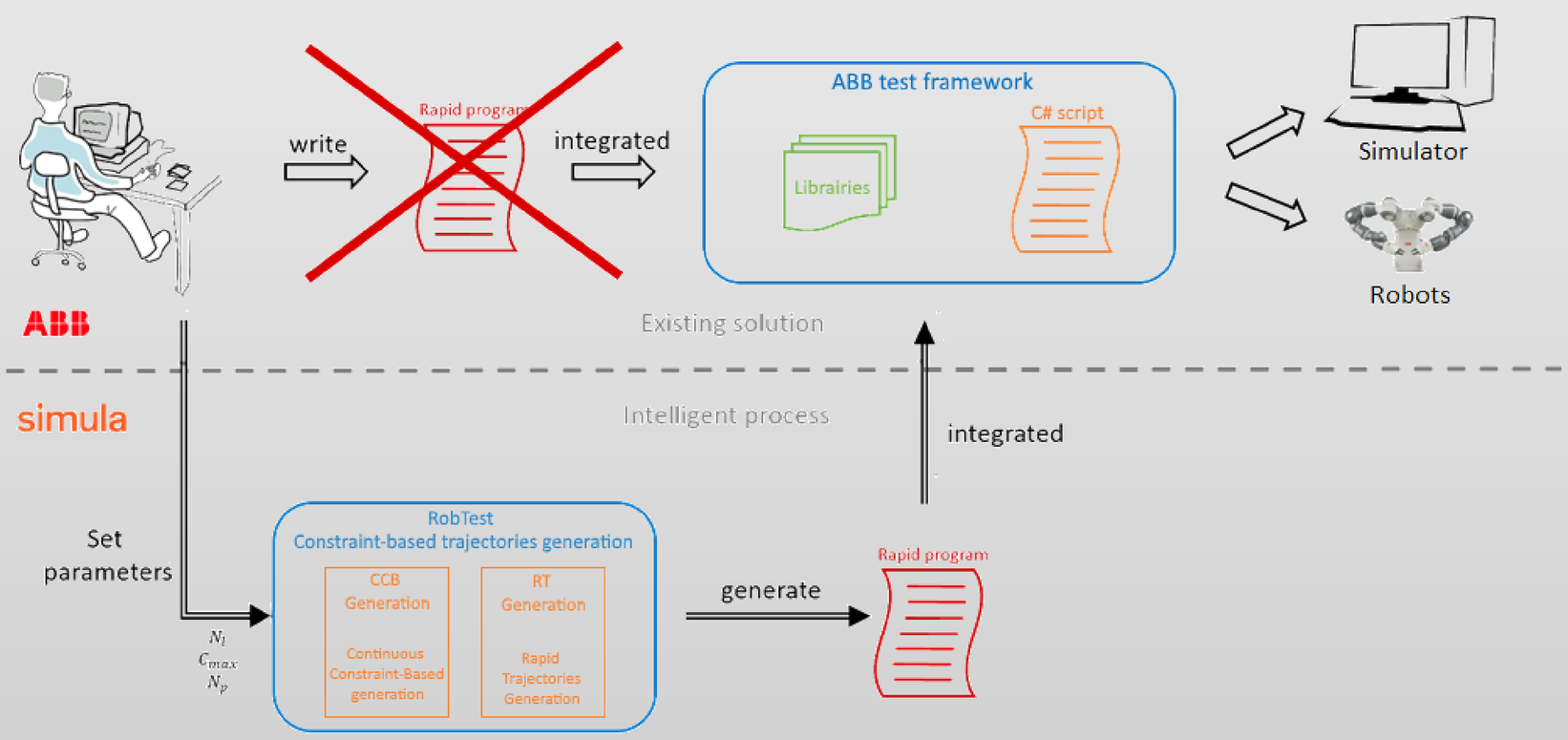
- Based on a **Dijkstra's algorithm**, some variation are added to get all the shortest paths.
- Use the accessibility matrix, which is a matrix of cost to perform the search
- The cost is a function taking into account differents parameters (distance, speed, zone, ...)
- Once the search is finished, the RAPID program is generated based on a template.

```
MODULE trajectories_test

    ! robtarget start here
    VAR robtarget p10 := [ [-300, -100, 300], …
    VAR robtarget p20 := [ [-200, 200, 300], …
    VAR robtarget p30 := [ [50, 300, 300], …
    VAR robtarget p40 := [ [300, 200, 300], …
    VAR robtarget p50 := [ [200, -75, 300], …

    PROC main()
        ConfL \Off;

        !Enter move-instructions here
        MoveJ p10,v1000,fine,tool0;
        MoveL p20,v500,fine,tool0;
        MoveC p40,v500,fine,tool0;
        MoveL p50,v500,fine,tool0;

    ENDPROC
ENDMODULE
```

Continuous Constraint Solver

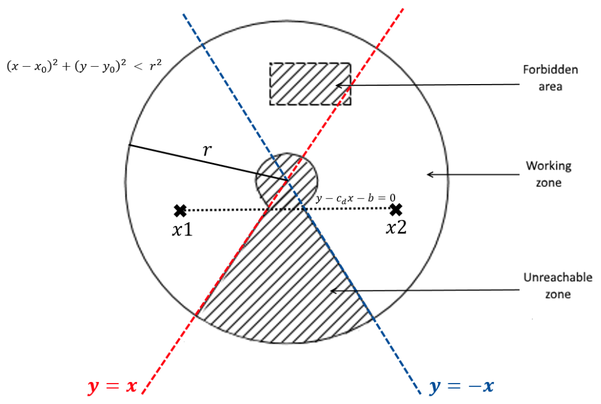
- Available though modeling languages for numerical constraints
- Solving non-linear constraints by interval computations which is useful since robot motions can be non linear
- The variables takes their values in the continuous domain
- Reduce the initial domain to give a set of solutions





Robot space configuration modelling

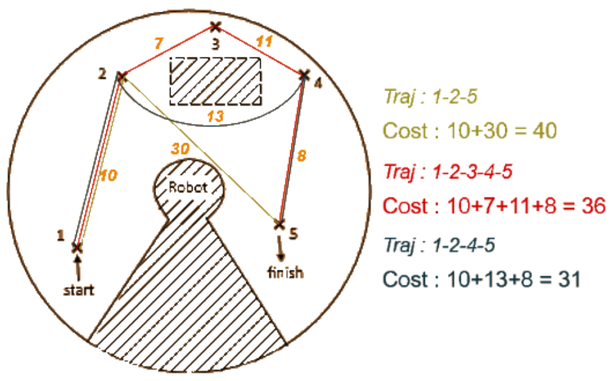
- The modelling of the space configuration is based on basic shapes (square, triangle, circle)



- The solver is based on Realpaver, and use to determine if a trajectory is crossing a forbidden zone

Trajectory definition

- N points are randomly inside the working zone
- A trajectory begin from a starting point, pass through N points and finish by an ending point



- Trajectory have a cost given by:

$$C_{tr} = \sum C_{edg}$$

Perspectives

- Multi-robot modelling
  - Integration of collision zone
  - Manage singularity points
  - Use 6D dimensions

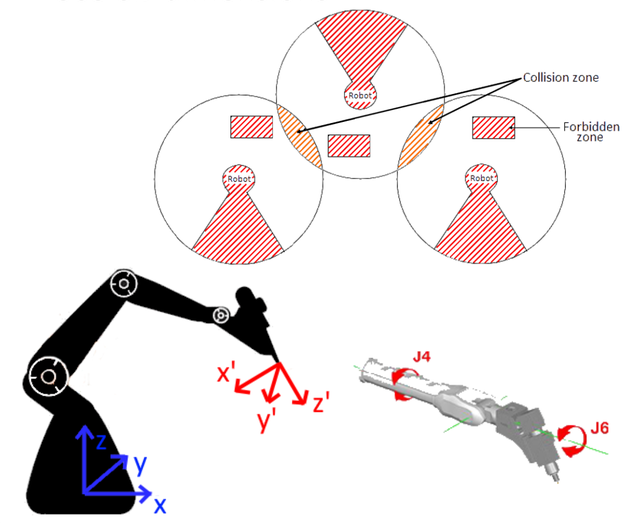


ABB
Power and productivity for a better world™

Universitetet i Stavanger

The Research Council of Norway

[simula . research laboratory]
- by thinking constantly about it

Certus

Contact :

mathieu@simula.no
mathieu.collet@no.abb.com