Reactive Obstacle Avoidance and Control Action Continuity. Application to the ND Algorithm

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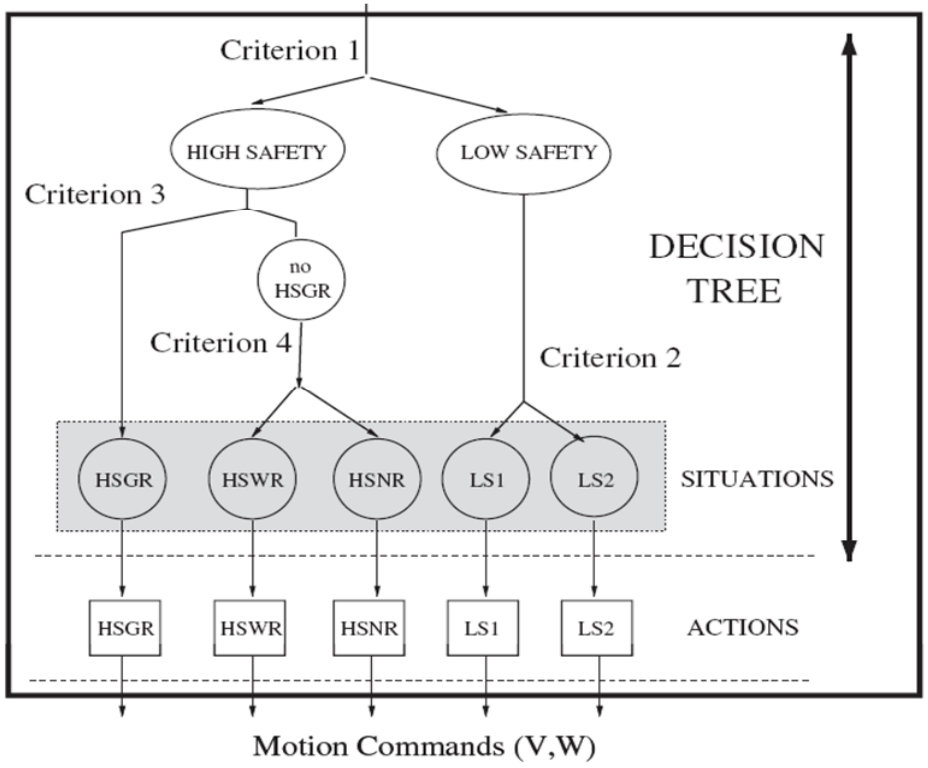
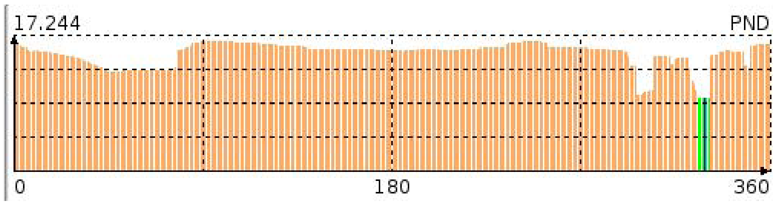
Context and motivation

Some navigation algorithms use situated action approach to apply different control rules as a function of robot detected environment.

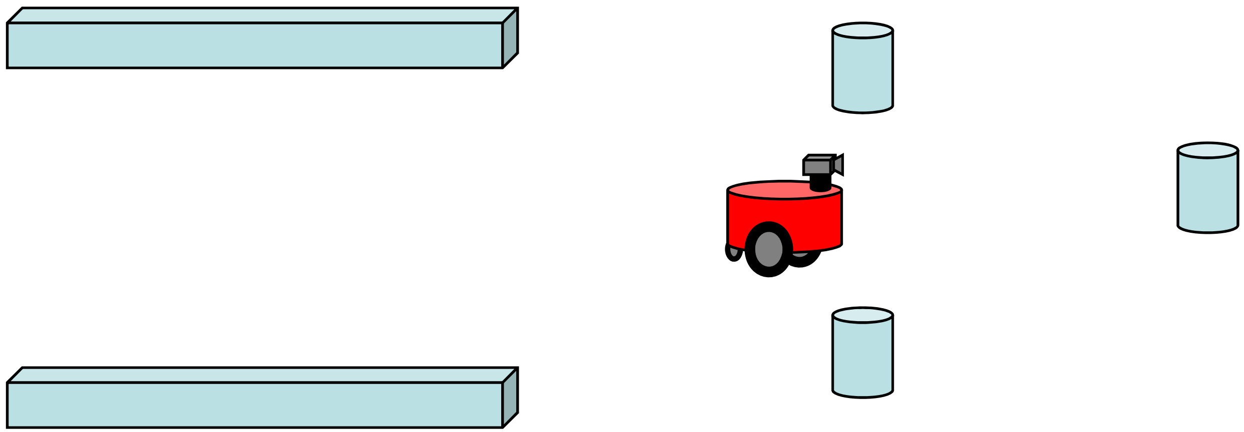


Example: Nearest Diagram Algorithm (ND), Minguez et. al. **"A Nearness diagram (ND) navigation: collision avoidance in troublesome scenarios",** <u>IEEE Transactions on Robotics and Automation, 2004</u>



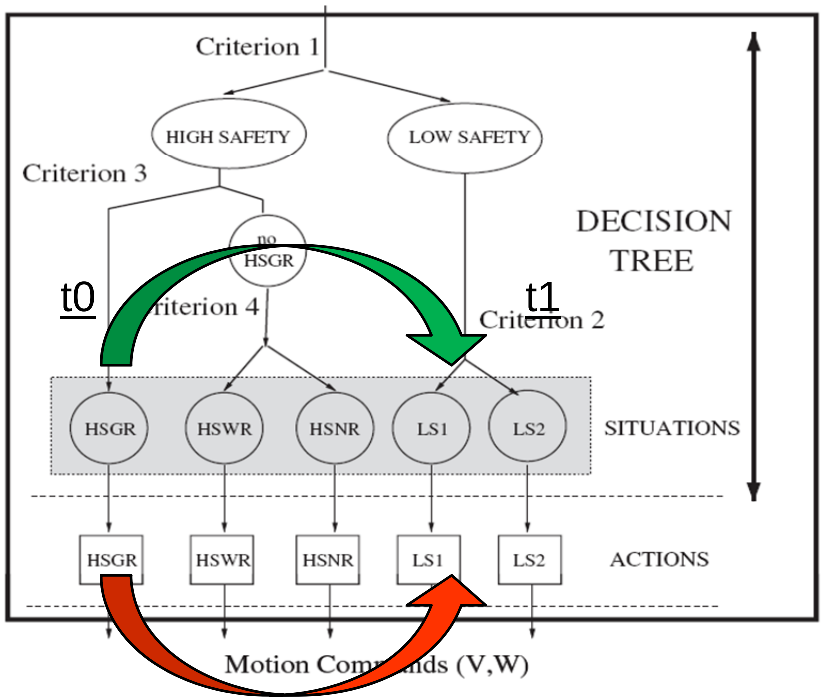
Context and motivation

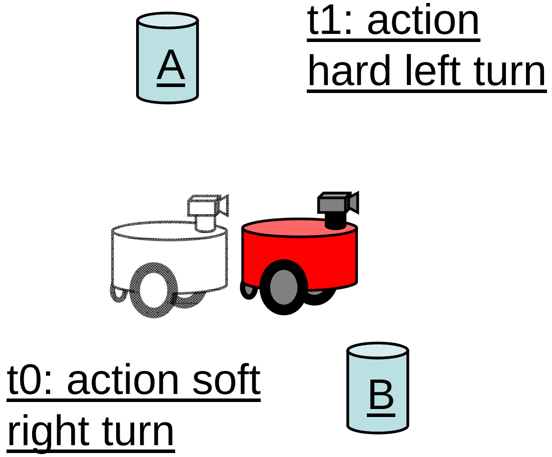
Advantages: instead of a general control rule, specific control rules are generated. The robot can apply different “navigation skills” depending on context (corridor traversing, door crossing, ...).



Context and motivation

Problem: control action continuity is normally not guaranteed when robot state evolves between different situations.





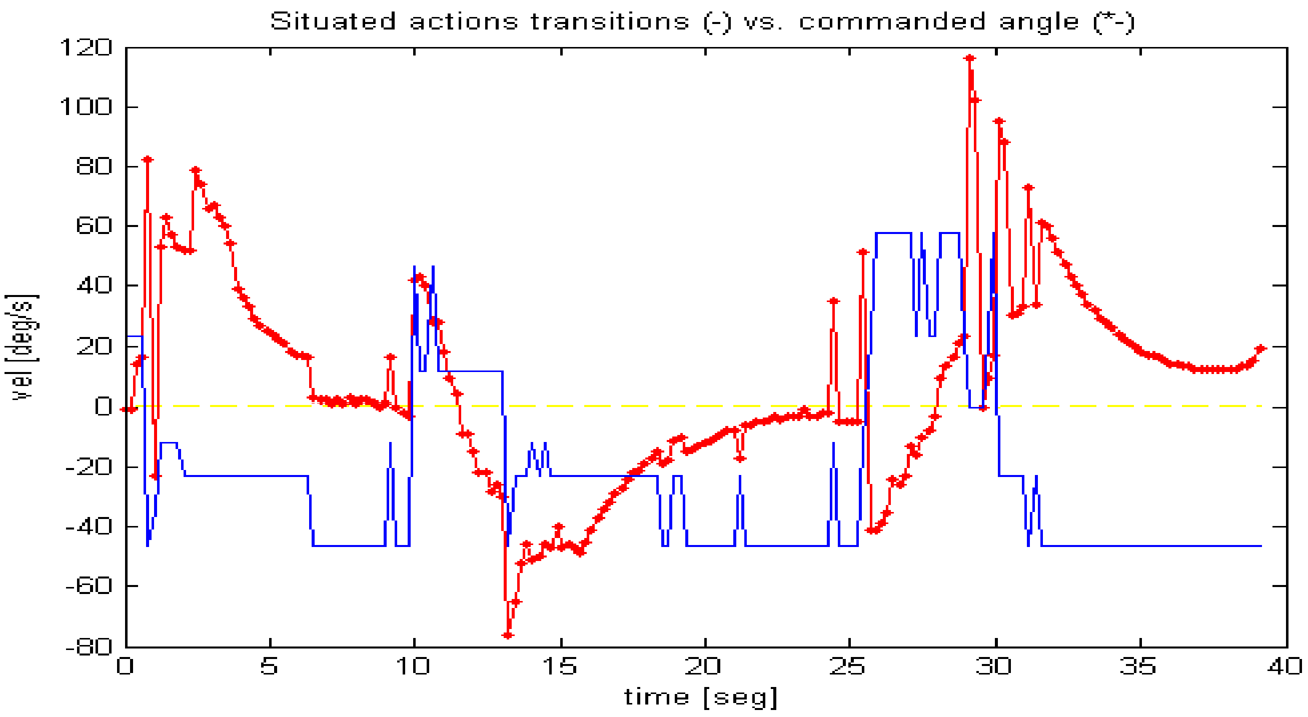
Context and motivation

The authors have considered this problem introducing the ND+ version of the algorithm, that analyzes the most common transitions and tries to reduce the transition situation effect.

Minguez et. al. **”A "divide and conquer" strategy based on situations to achieve reactive collision avoidance in troublesome scenarios”,** ICRA, 2004

Context and motivation

However: experimental results show that the continuity problem is still present.



Context and motivation

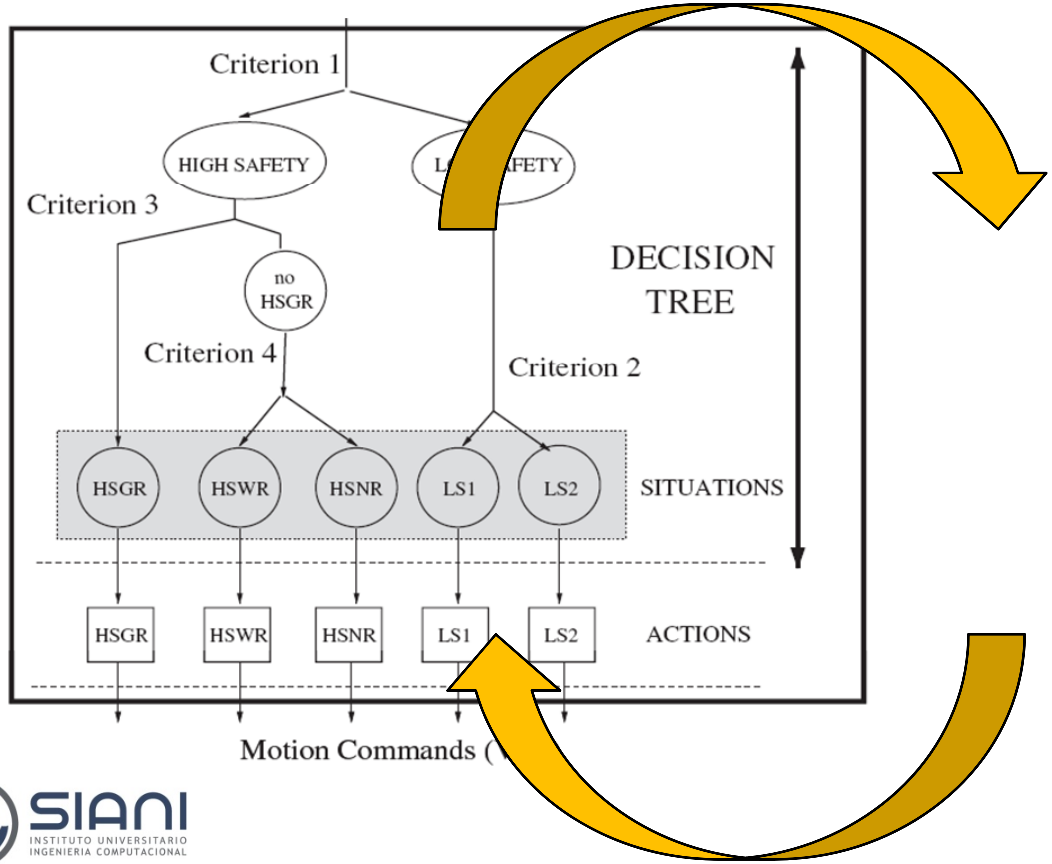
The problem is not easy to solve, as a balance between reactivity/safety and smoothness must be obtained.

An example of an inadequate solution is the use of a simple open-loop smoothness filter.

robotComand=newCommand(1-smoothFactor)+*
*previousCommand*smoothFactor*

Proposal

Proposed solution: define a kind of membership function (situation certainty) and weight the new generated command and the previous action using this value.



a) Select current situation applying the decision tree.

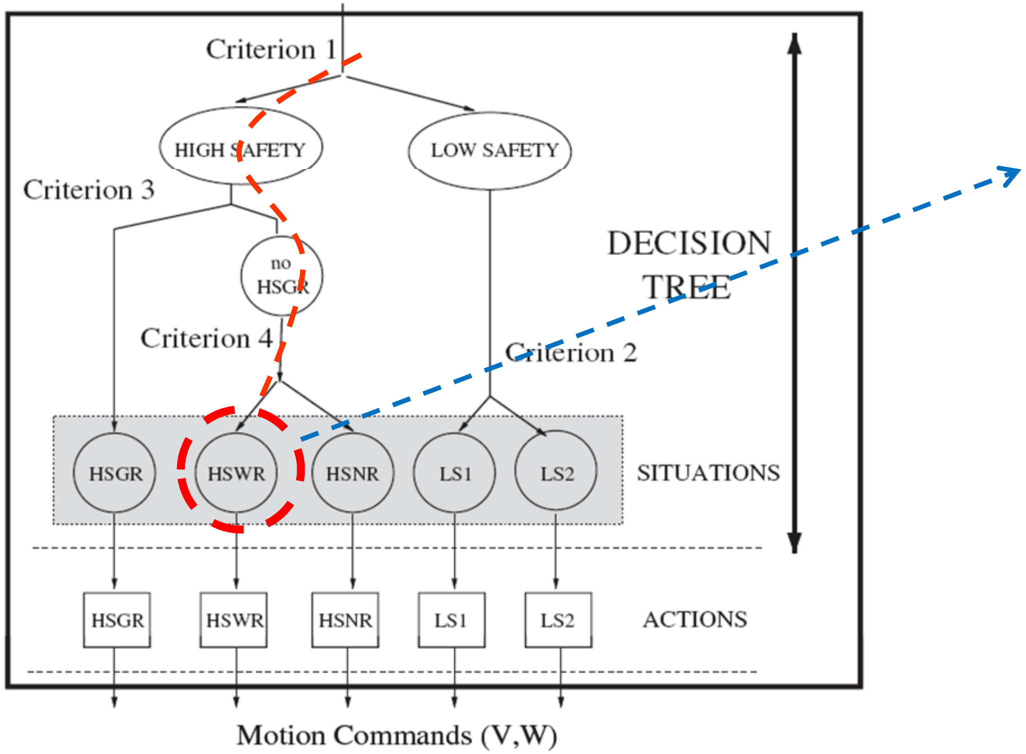
b) Compute situation certainty sCert (normalized).

c) Weight control action:

*com=newCom*sCert+*
prevCom(1-sCert)*

Proposal

The situation certainty is obtained as a combination of fuzzy values computed for each one of the decision criterions implicated.



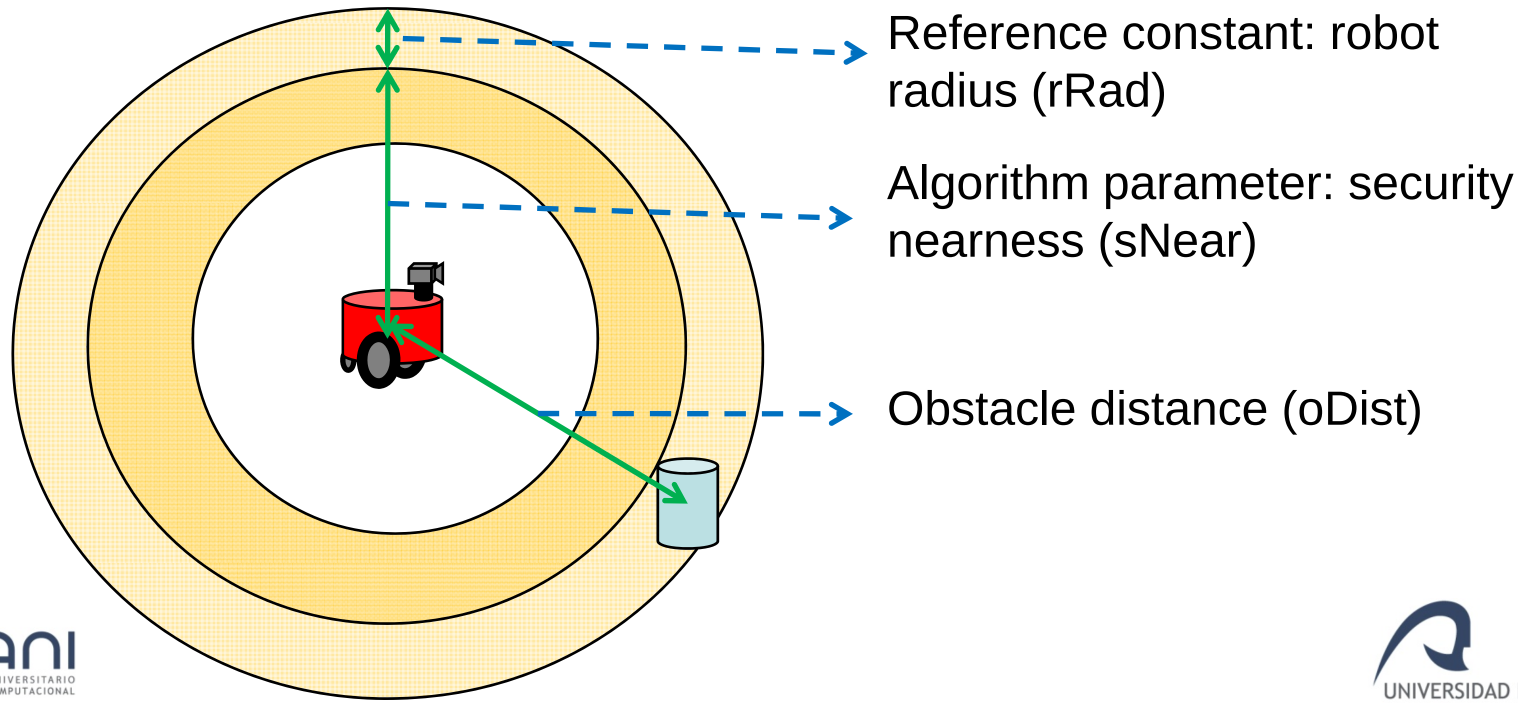
sCert=fun(crit1, crit3, crit4)

(fun type multiplicative, minimum, ...)

Proposal

For this certainty computation, each criterion is fuzzified using a ND algorithm parameter, a reference constant and a fuzzification factor.

Example: the first decision criterion (security criterion) is used to determine if there are obstacles inside a safety region around the robot.



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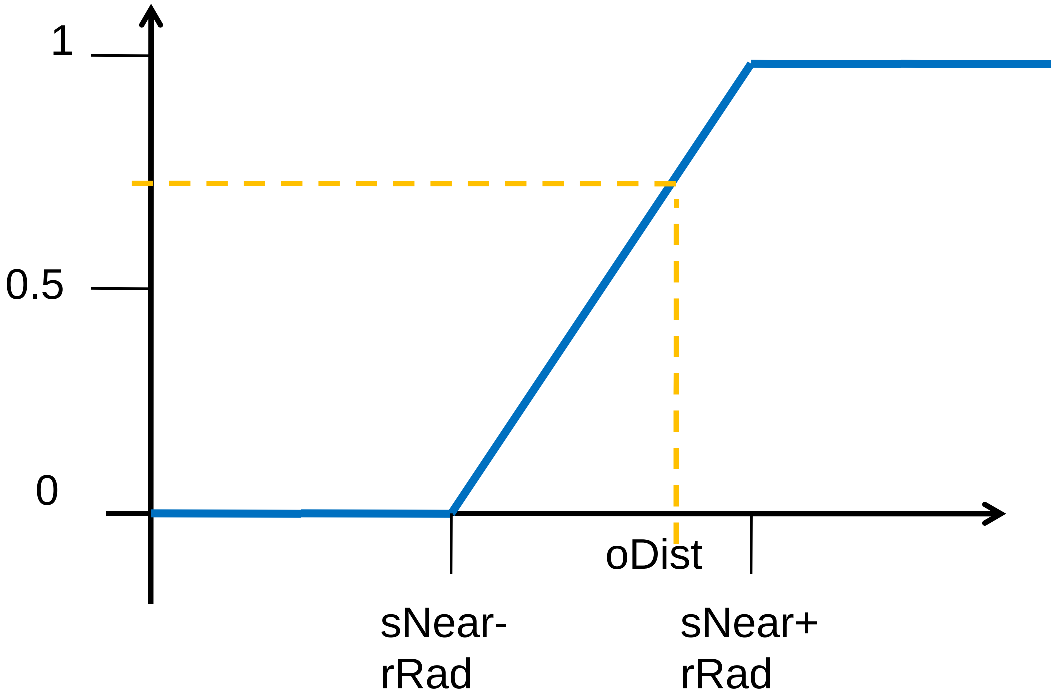
Proposal

Security criterion: fuzzy value computation



Results

For the validation of the proposal some experiments have been conducted on Player/Stage simulator using different scenarios.

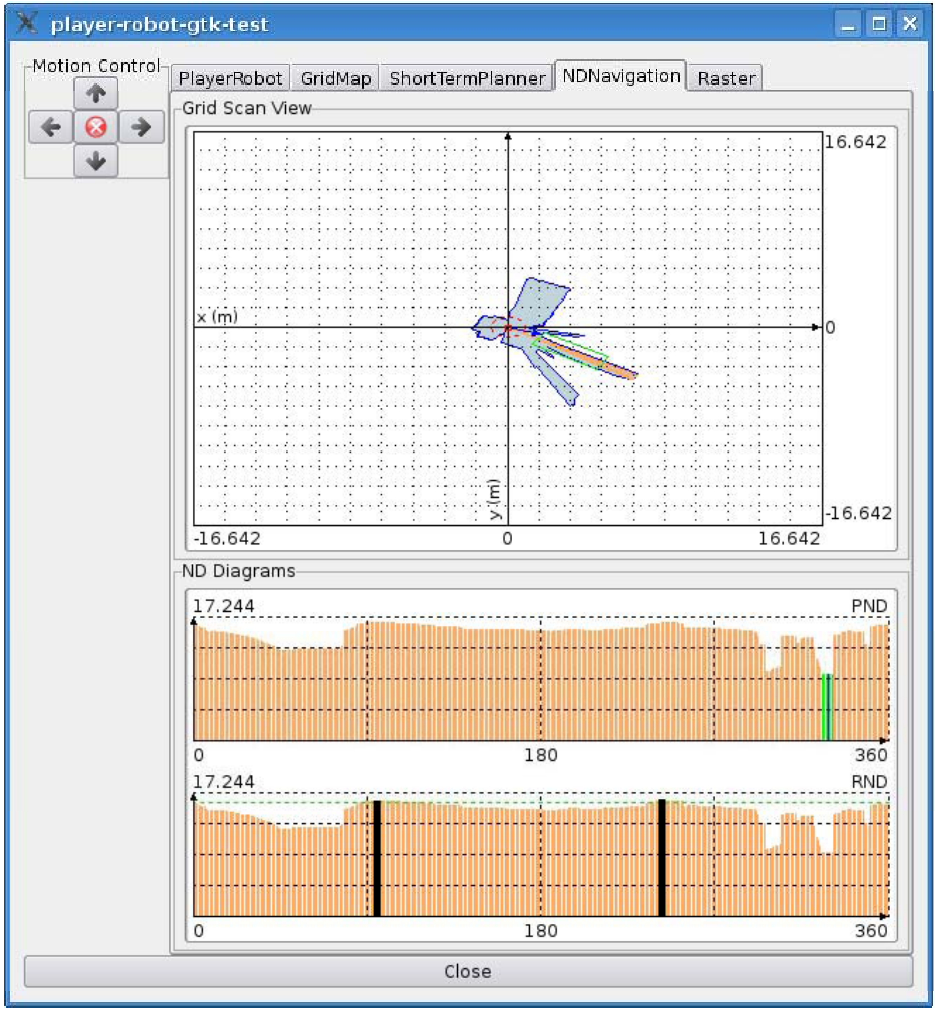
Besides the graphic-visual comparison, a benchmarking function has been defined for numerical evaluation.

Benchmarking factors:

- Time.
- Curvature ratio.
- Accelerations (trans, rot).

Results

Graphical application with debugging tools.

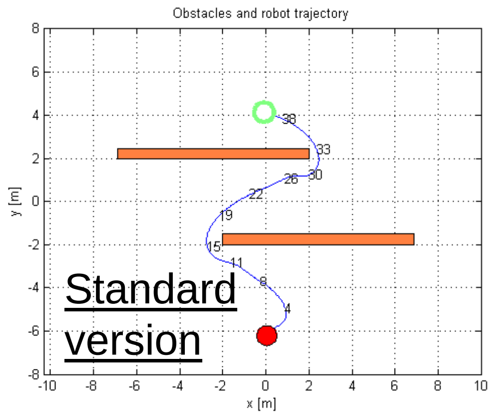


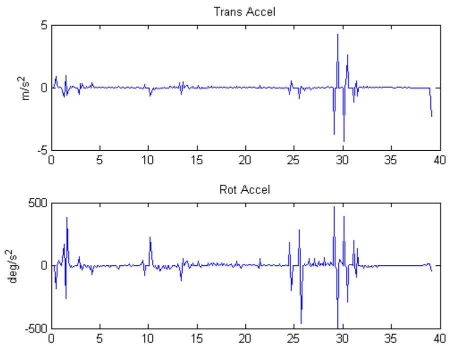
Results

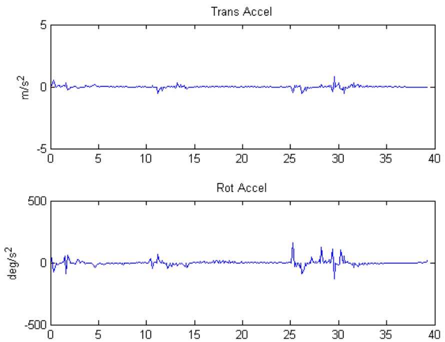
* Scenario 1

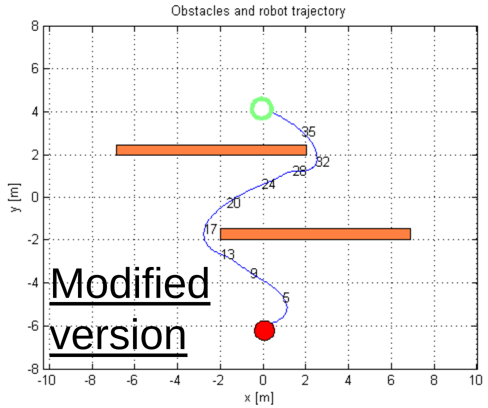
ND Standard

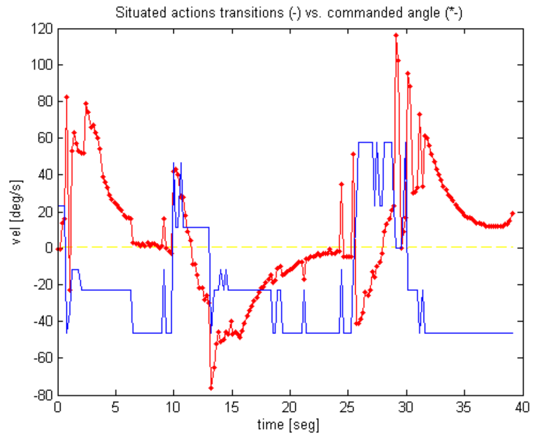
ND Modified

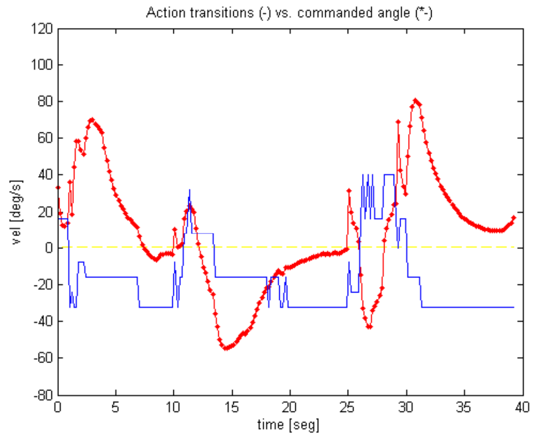












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Results

* Scenario 1

	$TimeF$	$CurvF$	$TAccelF$	$RAccelF$
Standard	0.52	0.39	0.18	0.72
Modified	0.52	0.41	0.47	0.85

TABLE I
BENCHMARKING FOR SCENARIO 1

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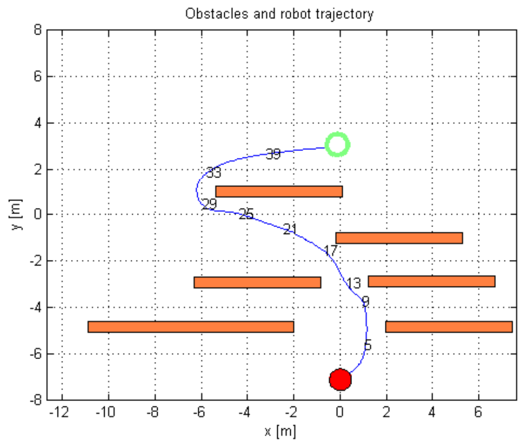
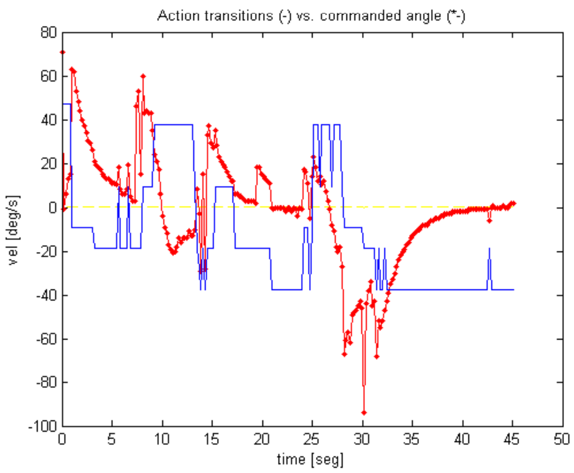
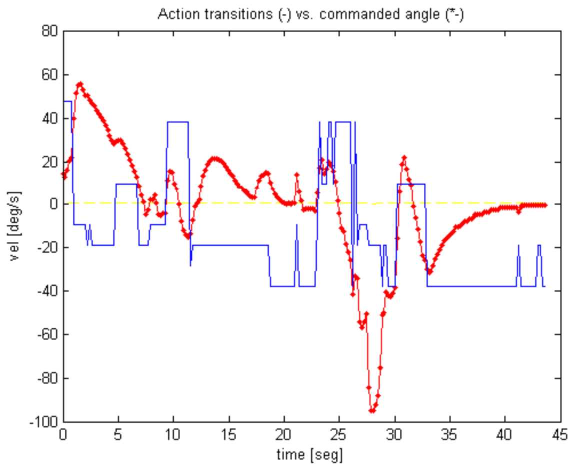
Results

* Scenario 2 ND Standard ND Modified







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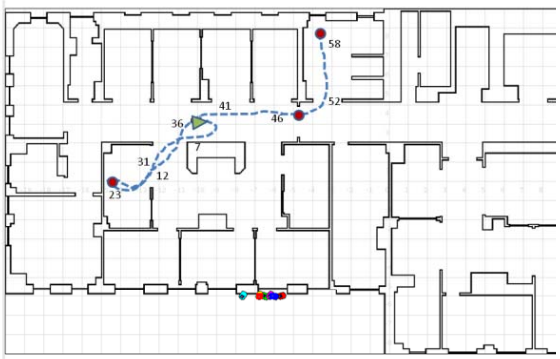
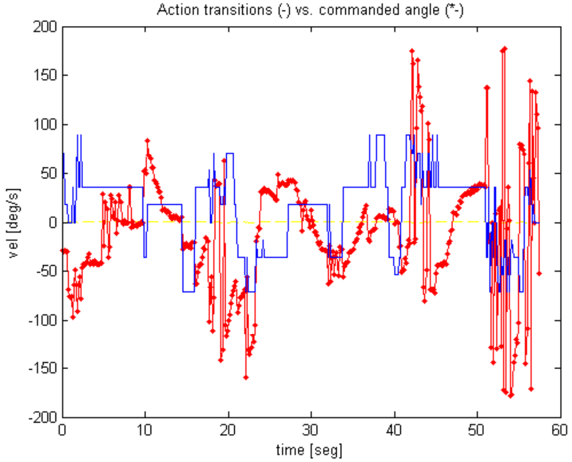
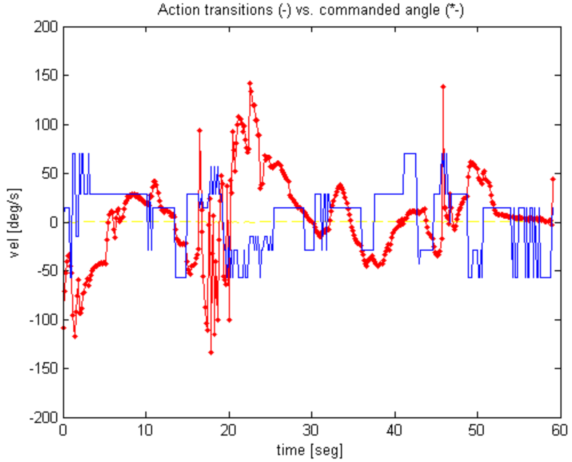
Results

* Scenario 3 ND Standard ND Modified







Future work

Analysis of parameters.

Combination of several situations.

Improve benchmarking.

Test on real robots.