HUMBOLDT-UNIVERSITÄT ZU BERLIN

Adaptive Motion Control: Dynamic Kick for a Humanoid Robot

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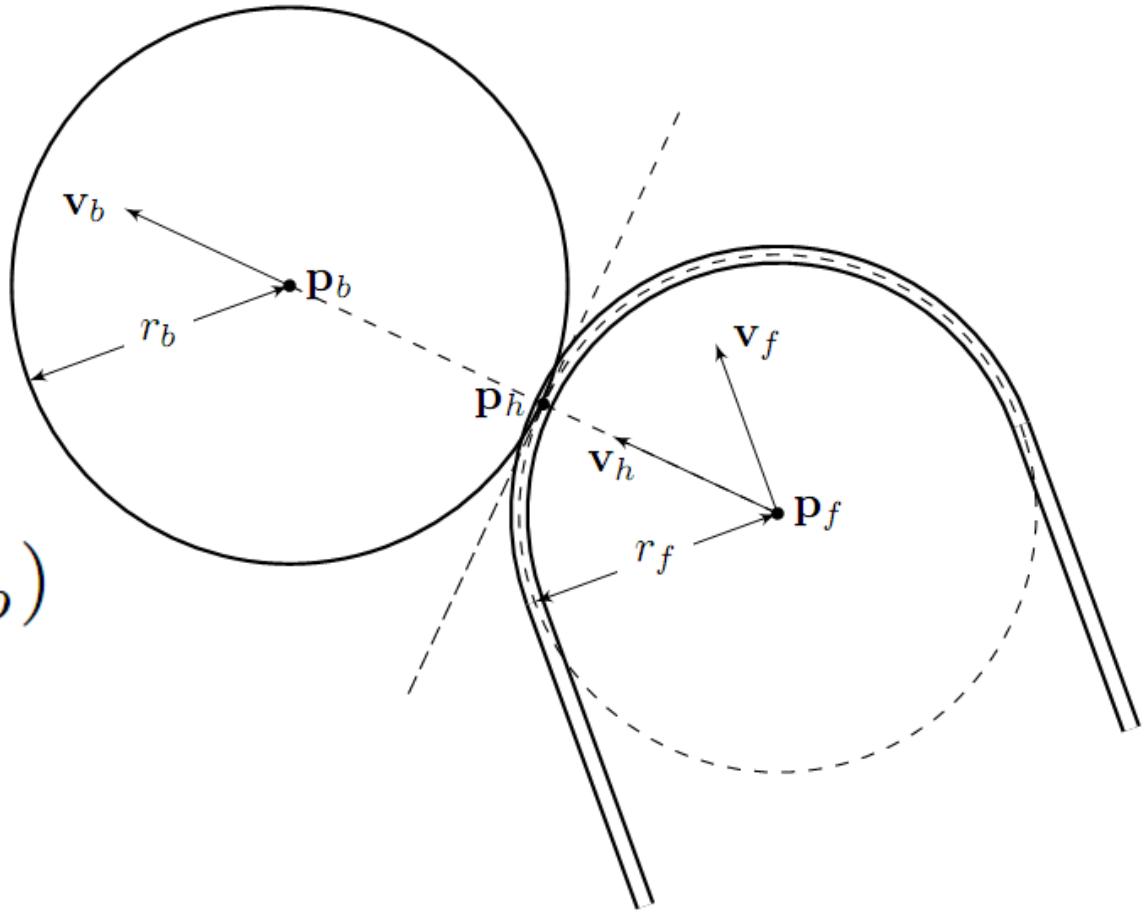
Outline

- Motivation
  - …what are we looking for?
- Definition of the kick task
  - …how to make a robot kick?
- Design of the Motion
  - …Reachable space, Motion planning, Stabilization
- Experiments
  - …applied to RoboCup
- Limits and Future Work
  - …what can we do better?

The Kick Task

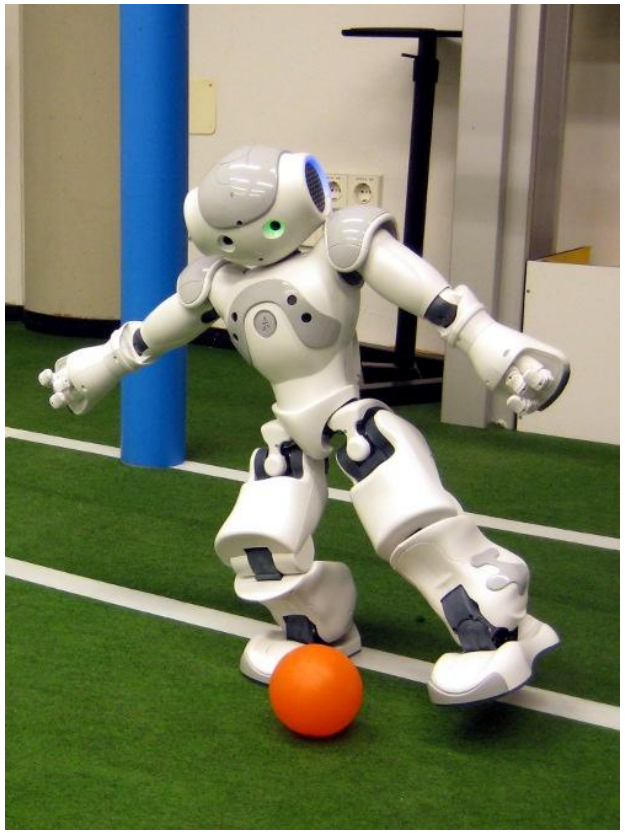


- kick request $(\mathbf{p}_b, \mathbf{v}_b)$
- hitting spot $\mathbf{p}_h$
- radius of the ball r_b
- radius of the foot r_f
- target of the foot motion $(\mathbf{p}_f, \mathbf{v}_f)$

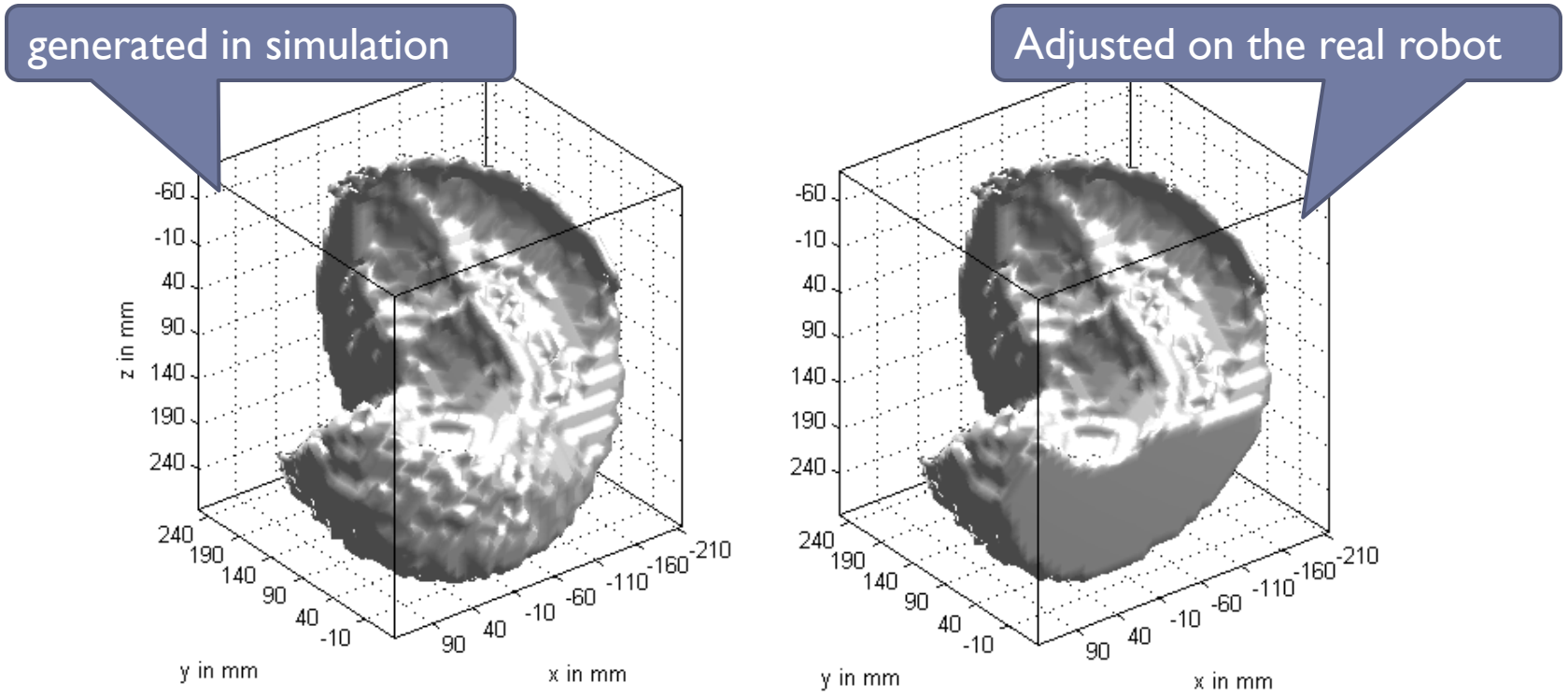
The Kick Task (2)

- Four Phases
  - Preparation
    - Move the robot to one foot
  - Retraction
    - Take the foot back according to the ball and the requested kick direction
  - Execution
    - Move the foot towards the ball to perform the kick
  - Wrap-up
    - Put the kicking foot back to the ground and move the body back to the center

- Important Aspects
  - Reachable space
  - Motion Planning
  - Stabilization

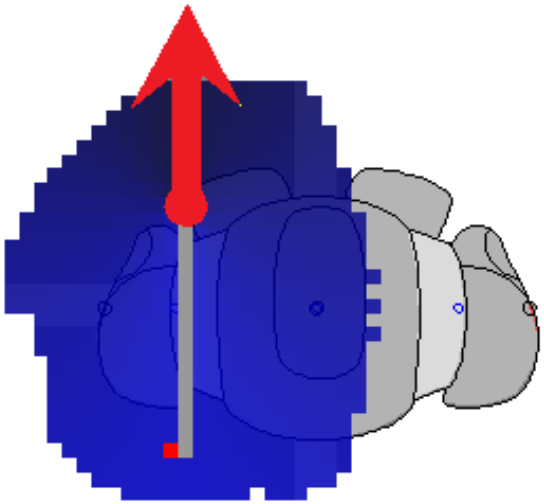


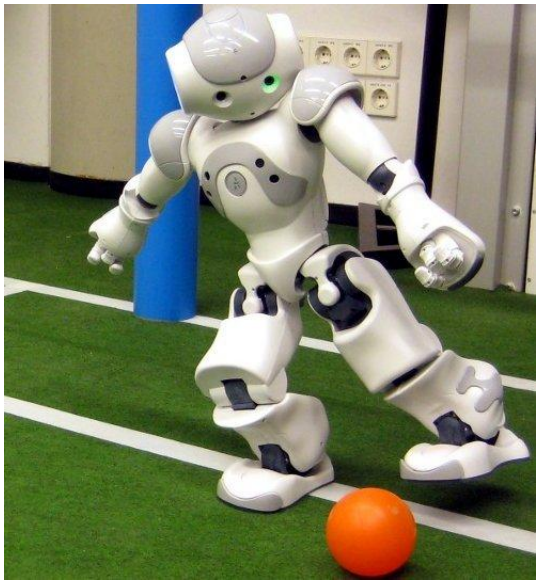
Reachable Space



- is defined by
  - the kinematic constraint (limits of joint angles, collision constraint)
  - the balance constraint
- is represented by a 3D grid

Retraction Point





- Find the retraction point as the maximum of

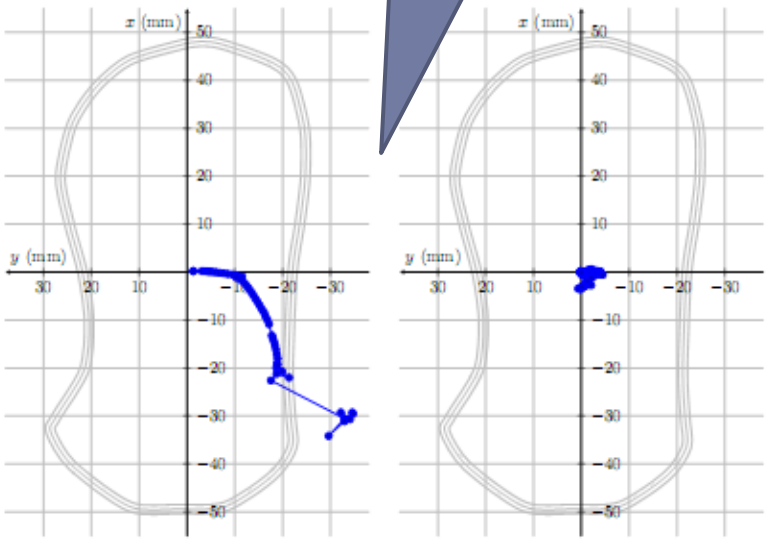
$$f_\delta(\mathbf{p}) := (1-\delta)\cdot\|\mathbf{p}-\mathbf{p}_h\| + \delta\cdot\left(1+\frac{(\mathbf{p}_h-\mathbf{p})^t\cdot\mathbf{v}_h}{\|\mathbf{p}_h-\mathbf{p}\|}\right)$$

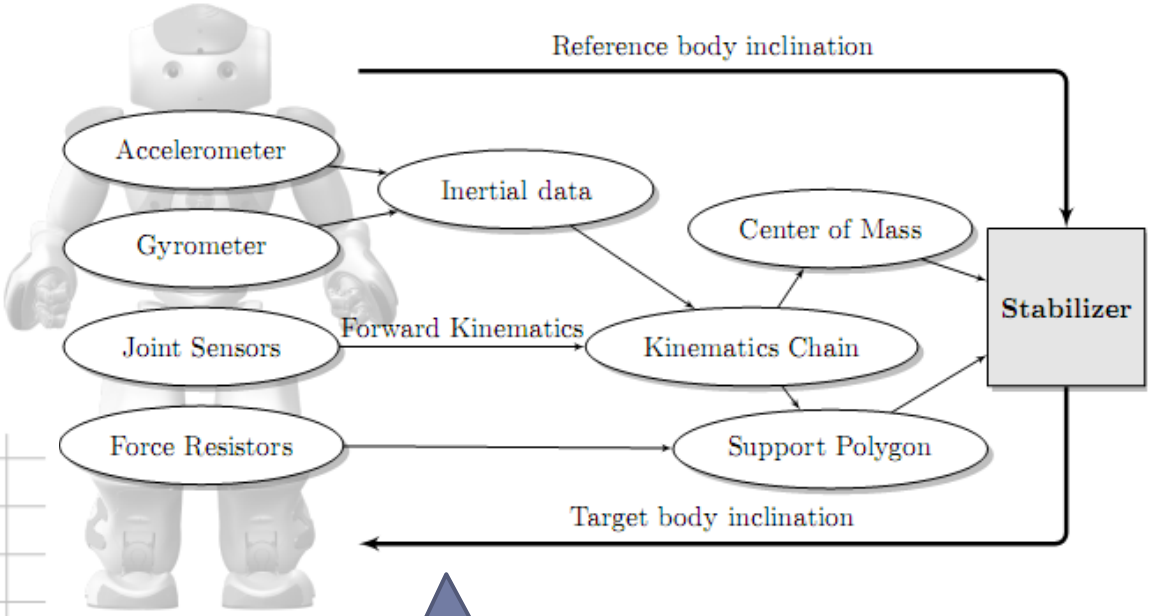
Retraction distance

kick direction

Body Inclination Control

Robot changes from double support to single support: without and with COG control





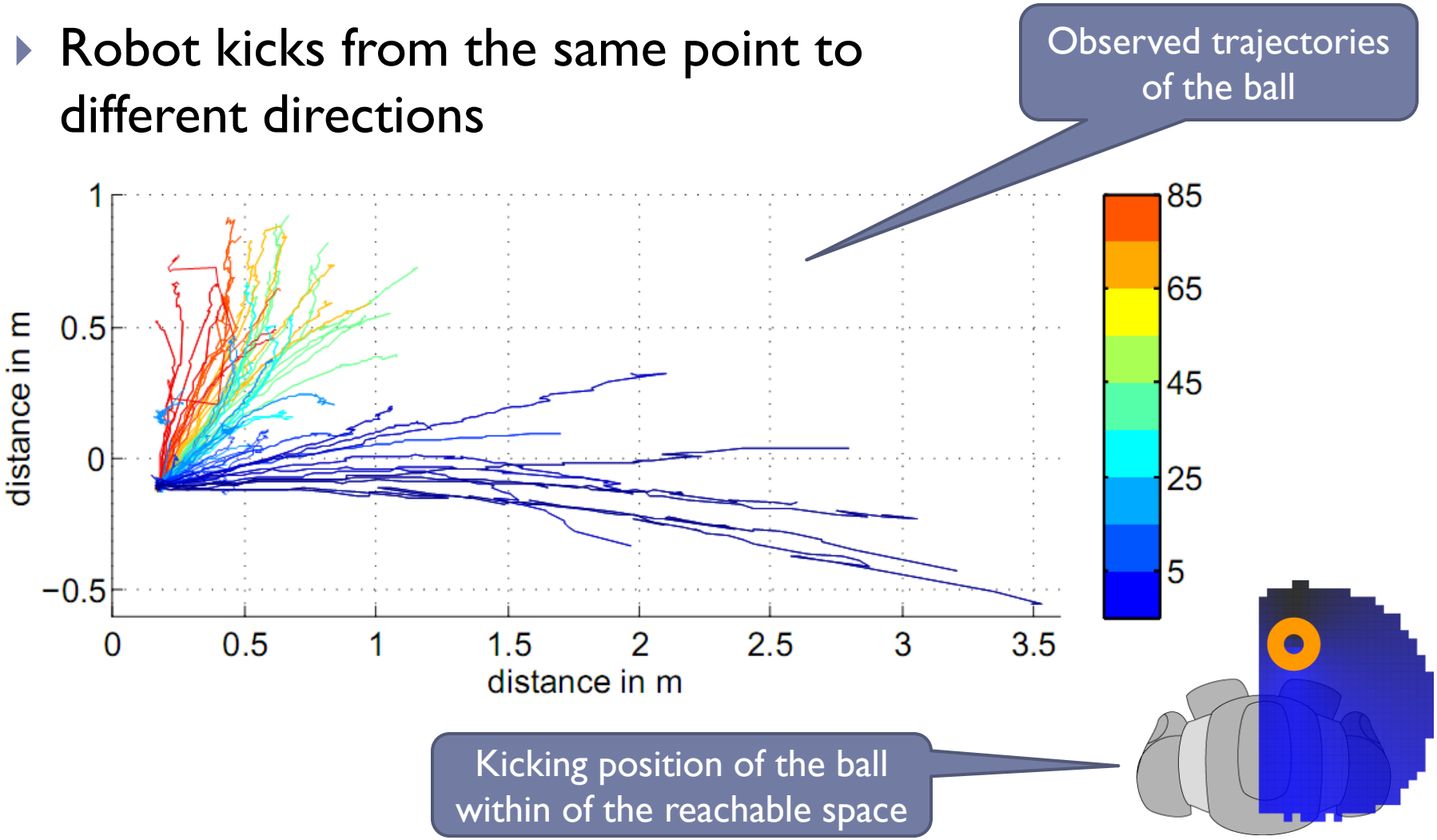
Center of mass is adjusted by a P controller

Video

- Video shows the kick experiments performt on the robot

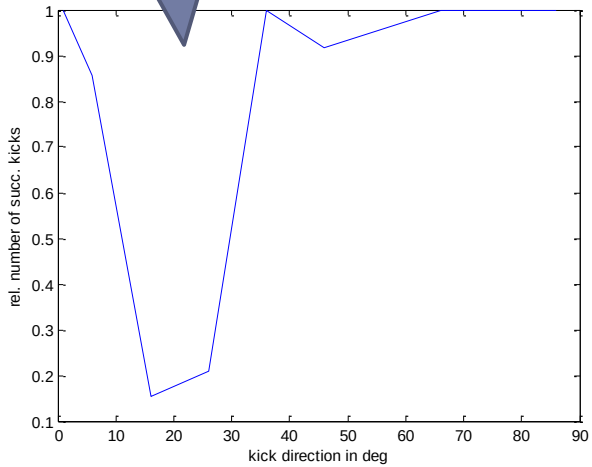
Experiments (varying direction)

- Robot kicks from the same point to different directions

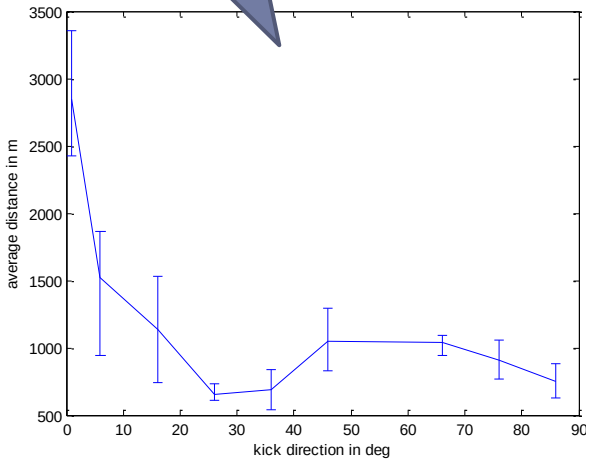


Experiments (error plots)

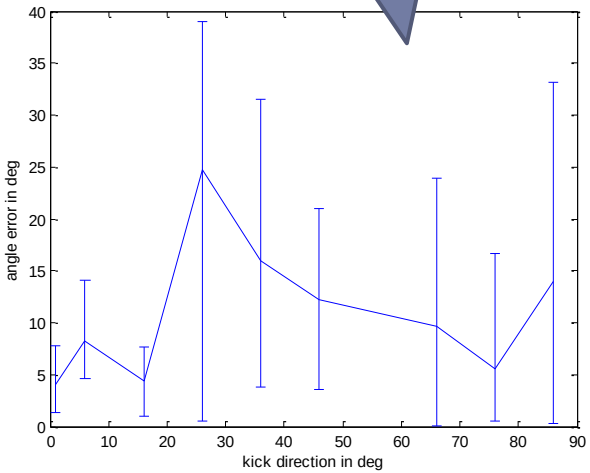
Relative number of kicks with the distance > 0.5m



Average distance

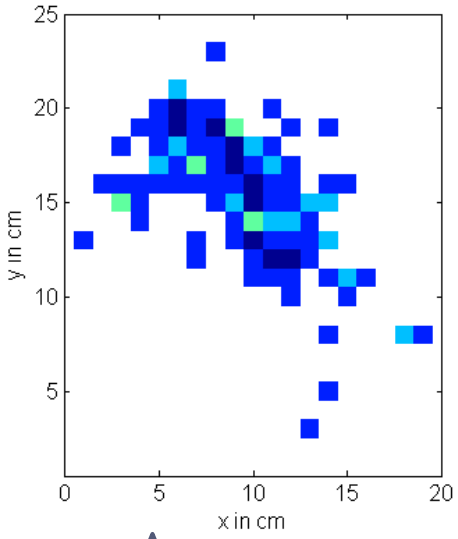


Average angle error



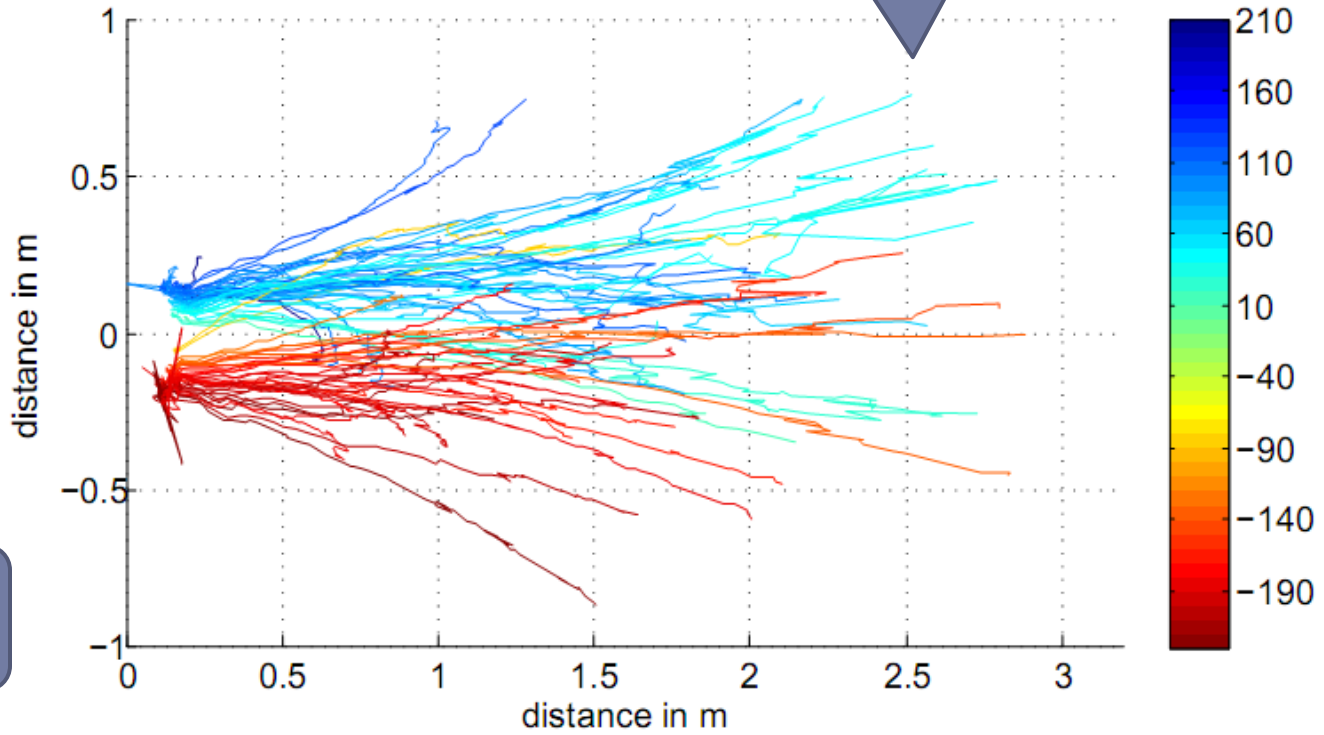
Experiment (varying position)

- Robot kicks forward from different positions



Kicking positions of the ball

Observed trajectories of the ball



Conclusion & Future Work

- Better stabilization during the kick execution
- Dynamic change between walk and kick

- Trajectory
  - Avoid collisions with other objects (e.g. ball)
  - Kick-trajectory planning in the joint space

- Machine Learning
  - to forecast the expected result
  - to increase the accuracy

Summary

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