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# Localization for Soccerrobots using Omnivision

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**Technical Aspects of Multimodal Systems**

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# Outline

Motivation Soccerrobot Omnidirectional Camera Possible Preprocessing Monte Carlo Method Field Geometry Usage Conclusion Sources

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2. Soccerrobot
3. Omnidirectional Camera
4. Possible Preprocessing
5. Monte Carlo Method
6. Field Geometry Usage
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  - White Line Pattern Match
  - Pattern Match with Motion
7. Conclusion
8. Sources



# Motivation

Motivation Soccerrobot Omnidirectional Camera Possible Preprocessing Monte Carlo Method Field Geometry Usage Conclusion Sources



[9] Soccergame



# Navigation

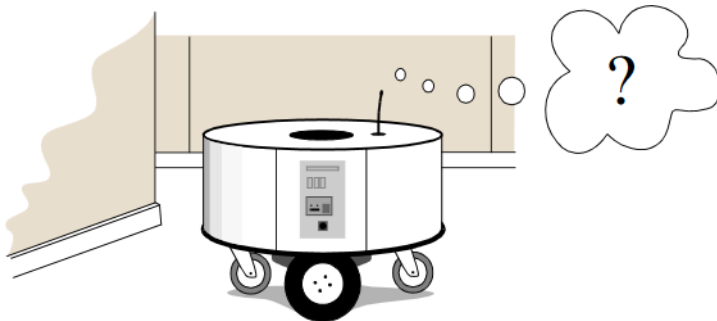
Motivation Soccerrobot Omnidirectional Camera Possible Preprocessing Monte Carlo Method Field Geometry Usage Conclusion Sources

- ▶ perception
- ▶ localization
- ▶ cognition
- ▶ motion control



# Localization

Motivation Soccerrobot Omnidirectional Camera Possible Preprocessing Monte Carlo Method Field Geometry Usage Conclusion Sources



[8] Where Am I ?

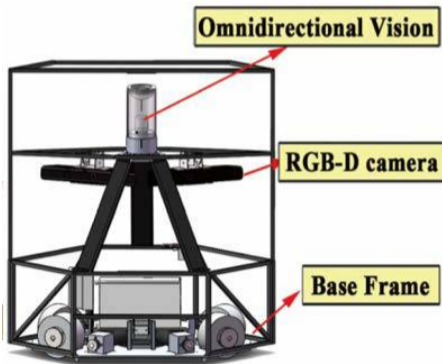


# Localization

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- ▶ is needed for navigation of mobile robots
- ▶ robot must determine its position in the environment
- ▶ Problem: Localization is not 100% accurate
  - ▶ sensor noise/-error
  - ▶ effect noise/-error





[9] Soccerrobot



# Omnidirectional Camera

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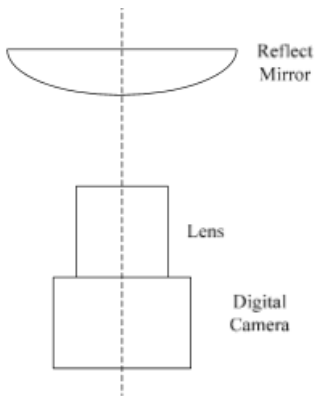
[7] Omnidirectional Camera





# Omnidirectional Camera

Motivation Soccerrobot **Omnidirectional Camera** Possible Preprocessing Monte Carlo Method Field Geometry Usage Conclusion Sources



[3] Omnidirectional Camera Scheme

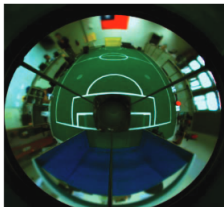




# Omnidirectional Camera

Motivation Soccerrobot **Omnidirectional Camera** Possible Preprocessing Monte Carlo Method Field Geometry Usage Conclusion Sources

- ▶ ideal omnidirectional camera capture light from every direction
- ▶ in practice often only 360 degree around the equator with top and bottom cut off
- ▶ if full sphere is covered, more than one focal point



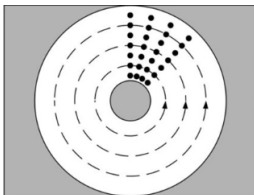
[4] Image from Omnidirectional Camera



# Possible Preprocessing

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- ▶ because omnidirectional images are very distorted, it is possible to calculate a normal (panoramic) picture
- ▶ also for most approaches scanlines are added



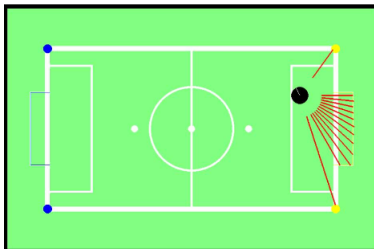
[1] Scanlines



# Monte-Carlo Self-Localization

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- ▶ using particle filter for localization
- ▶ each particle is estimation of robots position
- ▶ particles are updated over time

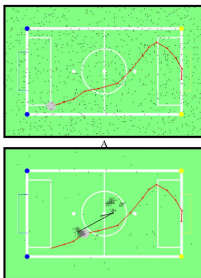


[2] Expected Scan

# Advantages and Disadvantages

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- ▶ Advantages:
  - ▶ very good with many particles
  - ▶ fast with few particles
- ▶ Disadvantages:
  - ▶ high computational cost with many particles
  - ▶ not very good with few particles



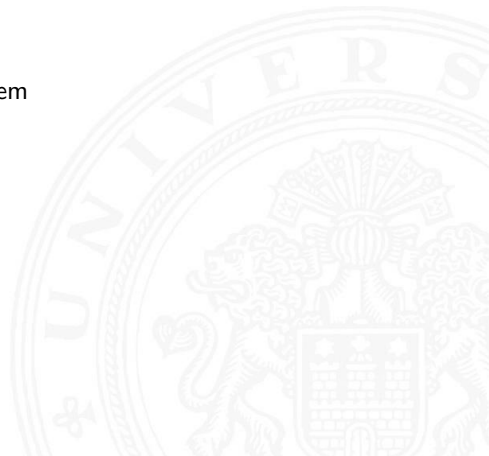
[2] Many and Few Particles Used



# Dual-Circle Self-Localization

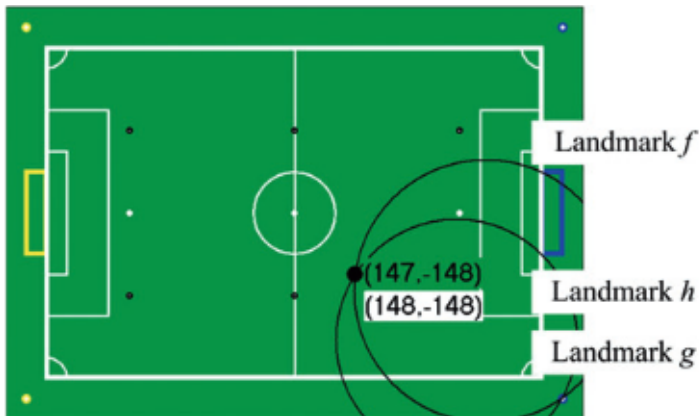
Motivation Soccerrobot Omnidirectional Camera Possible Preprocessing Monte Carlo Method Field Geometry Usage Conclusion Sources

- ▶ uses known landmarks in the environment for localization
- ▶ uses a hybrid scanning method
  - ▶ Gap Scanning
  - ▶ Polar Scanning
- ▶ uses two coordinate systems
  - ▶ field coordinate system
  - ▶ robot center coordinate system

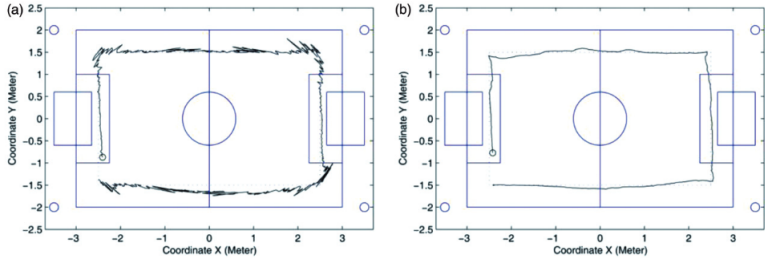


# Simulation

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[1] Simulation for DCSL



## [1] Experiment for DCSL without and with Kalman Filter





# Advantages and Disadvantages

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- ▶ Advantages of Dual-Circle Self-Localization
  - ▶ faster than Monte-Carlo Localization
  - ▶ more precise than Monte-Carlo Localization
- ▶ Disadvantages of Dual-Circle Self-Localization
  - ▶ sensitive to changes in lighting conditions

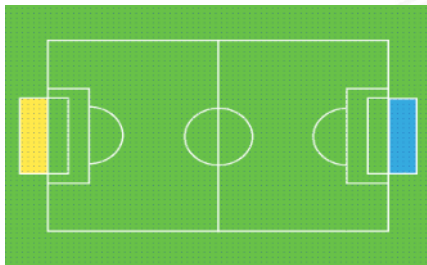




# White Line Pattern Match Localization

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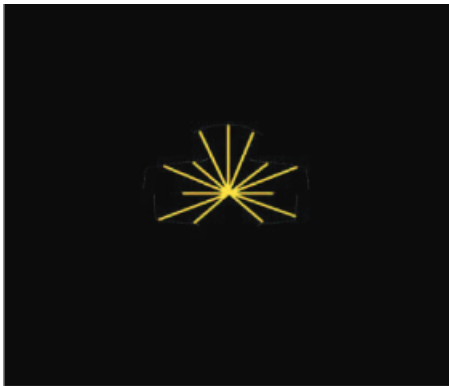
- ▶ uses a grid for localization
- ▶ looks at the first white pixels found on scan lines
- ▶ uses a built-in database to compare position using nearest distance



[4] Visualization of the Grid

# Scan Lines

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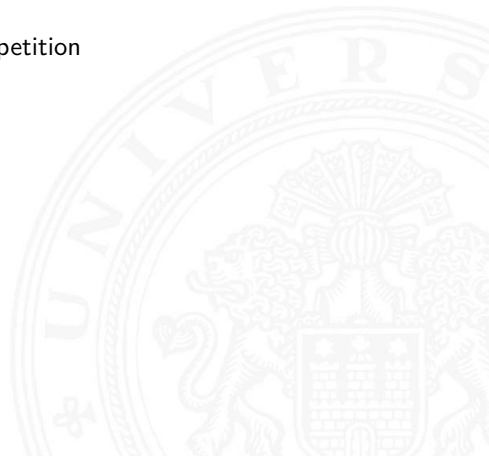
[4] Visualization of the Scanlinevector



# Advantages and Disadvantages

Motivation Soccerrobot Omnidirectional Camera Possible Preprocessing Monte Carlo Method Field Geometry Usage Conclusion Sources

- ▶ Advantages:
  - ▶ very fast
  - ▶ robust to illumination changes
- ▶ Disadvantages:
  - ▶ poor reliability
  - ▶ not competitive in real competition



# Pattern Match with Motion Information

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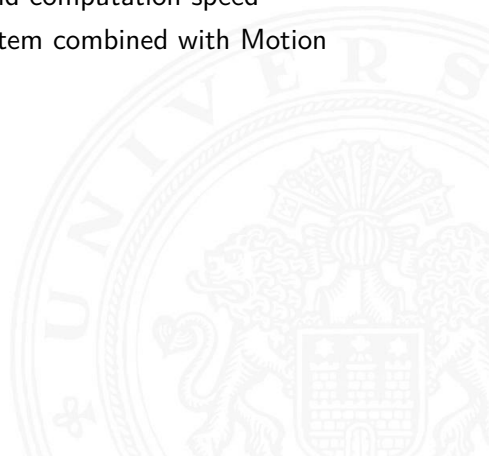
- ▶ uses motion information to make pattern match more robust
- ▶ still very fast



[5] Omnidirectional Moving Base of Robot



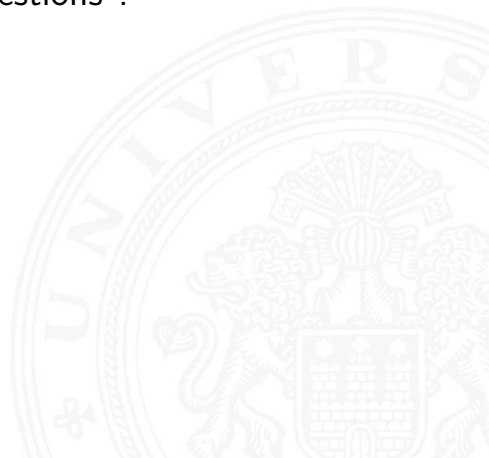
- ▶ many different approaches for omni-vision based self-localization
- ▶ has to work towards real-time
- ▶ trade-off between precision and computation speed
- ▶ Current approach: Vision System combined with Motion System Data





# Thank You!

Any Questions ?





- ▶ [1] Chen-Chien Hsu, Ching-Chang Wong, Hung-Chih Teng, Cheng-Yao Ho, "Dual-Circle Self-Localization for Soccer Robots with Omnidirectional Vision", Journal of the Chinese Institute of Engineers, Vol. 35, Issue 6, Pages619-631, 2012
- ▶ [2] E. Menegatti, A. Pretto, A. Scarpa, E. Pagello, "Omnidirectional Vision Scan Matching for Robot Localization in Dynamic Environments", IEEE Transactions on Robotics, Vol. 22, Issue 3, pp.523-535, 2006
- ▶ [3] Bo Liu, Junbo Fan Jun Zhou Kui Ki, Yongzhao Xie, "A Self-Localization Method through Pose Point Matching for Autonomous Soccer Robot Based on Omni-Vision", the 9th International Conference on Electronic Measurement and Instruments, pp.4-246 - 4-249, 2009





- ▶ [4] Shu-Yin Chiang, Xingzhi Guo, Hsien-Wen Hu, "Real Time Self-Localization of Omni-Vision Robot by Pattern Match System", 2014 International Conference on Advanced Robotics and Intelligent Systems, Taipei, Taiwan, 2014
- ▶ [5] Shu-Yin Chiang, Chi-An Wei, Ching-Yi Chen, "Real-Time Self-Localization of a Mobile Robot by Vision and Motion System", International Journal of Fuzzy Systems, Vol. 18, No. 6, 2016
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- ▶ [7] [https://en.wikipedia.org/wiki/Omnidirectional\\_camera#/media/File:Omnidirectional\\_camera\\_numbered.PNG](https://en.wikipedia.org/wiki/Omnidirectional_camera#/media/File:Omnidirectional_camera_numbered.PNG)



- ▶ [8] R. Siegwart, I. R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", pp.181-188, The MIT Press, Cambridge, Massachusetts, 2004
- ▶ [9] Dan Xiong, Junhao Xiao, Huimin Lu, Zhiwen Zeng, Quingua Yu Kaihon Huang, Xiadong Yi, Zhiqiang Zheng, "The Design of an Intelligent Soccer-Playing Robot", Industrial Robot: An International Journal,,Vol. 43, No. 1, pp. 91-102, 2016