Robot Coordination

Jonas Hagge

University of Hamburg
Faculty of Mathematics, Informatics and Natural Sciences
Department of Informatics
Technical Aspects of Multimodal Systems

16. May 2019

Outline

1. Introduction
   - Motivation
   - History
2. Finite State Machine
3. Hierarchical FSM
4. Subsumption
5. Decision Trees
6. Behavior Trees
   - Example
7. Dynamic Stack Decider
   - example
8. Conclusion

Motivation

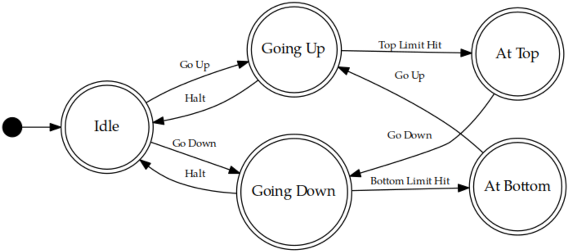
- controlling behavior of the robot
- diverse sensors/actuators
- uncertainty
- real time

History

[1] Robot Shakey had camera, range finder, bump sensor

SPA-Paradigm (sense-plan-act)
[2, 3]

Finite State Machine

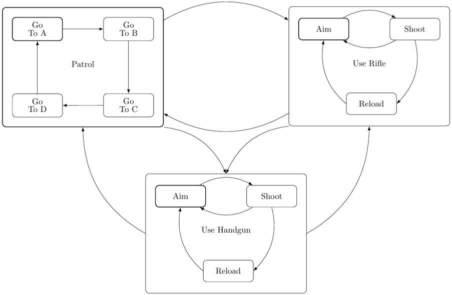


[4]

- finite set of states
- possible inputs are alphabet of symbols
- transition between states

[5]

Hierarchical Finite State Machines

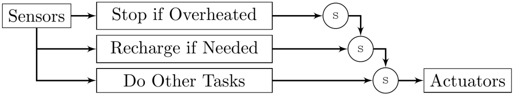


[7]

- developed to alleviate disadvantages of FSM
- states can contain other states
- superstates

[7]

Subsumption



[7]

- planning in SPA took too long
- robot would be blocking during planning
- -> layer of finite-state-machines
- higher level behavior can override lower level behavior

[2]

Decision Trees

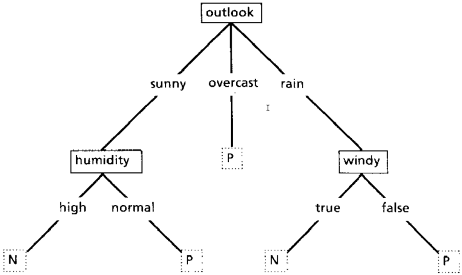


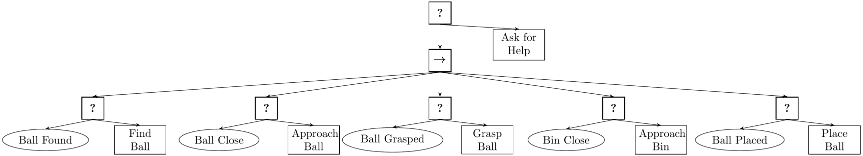
Figure 2. A simple decision tree

[6]

- used for AI problems
- used for calculating probabilities

[5]

Behavior Trees

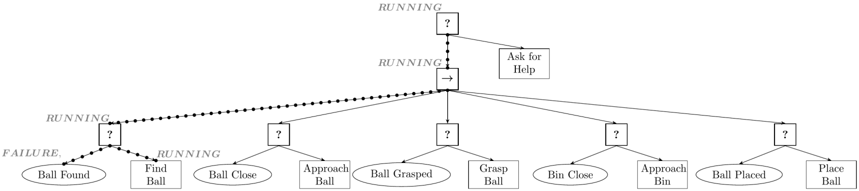


[7]

- tick driven
- directed rooted tree
- internal nodes: control flow nodes
- leaf nodes: execution nodes
- nodes can return: Running, Success, Failure

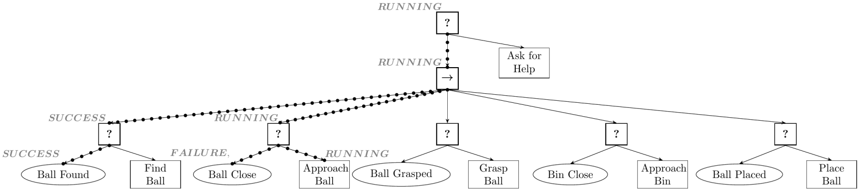
[5, 8]

Behavior Tree Example



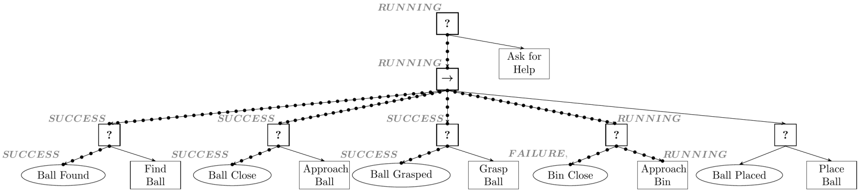
[7]

Behavior Tree Example



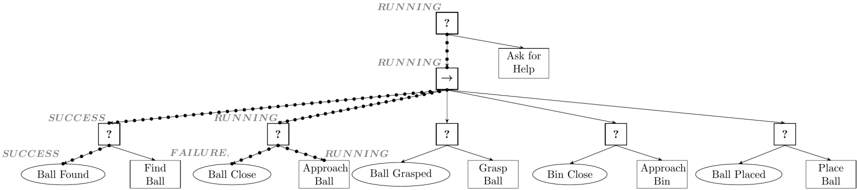
[7]

Behavior Tree Example



[7]

Behavior Tree Example



[7]

DSD - Dynamic Stack Decider

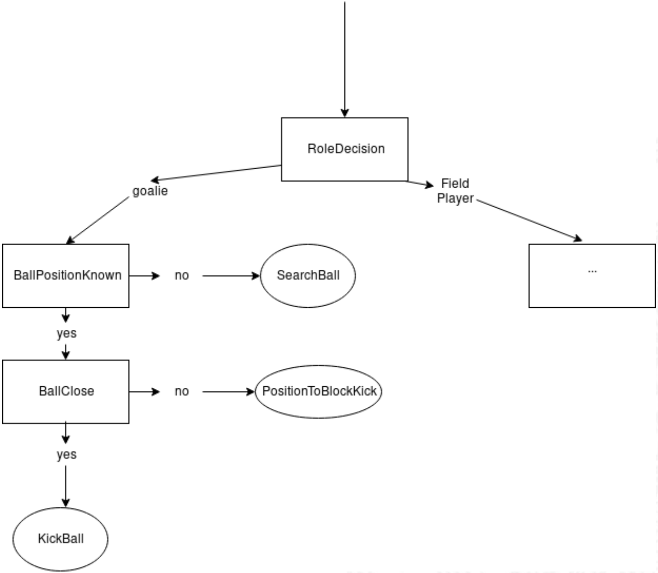
- uses own Description Language

  $name (decision)
  @name (action)
  - - > "Return Value" - - > $,@Name
  #name (subtree)
  + $,@ name + param: p_value

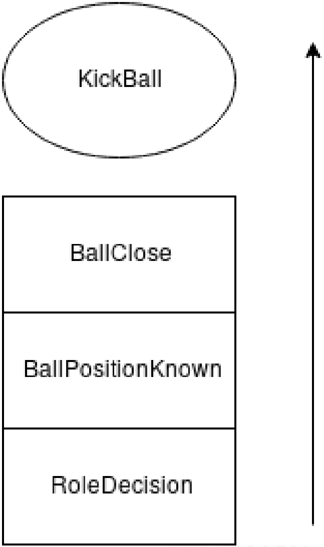
- used for robot soccer
- used by IROS 2018 Mobile Manipulation Hackathon winner (TAMS)

[5]

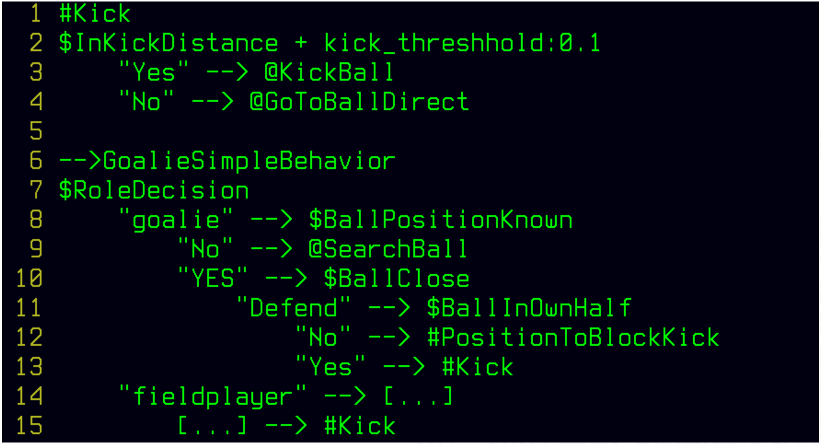
DSD Example


RoleDecision
goalie
Field Player
BallPositionKnown
no
SearchBall
...
yes
BallClose
no
PositionToBlockKick
yes
KickBall

Example DSD Stack



DSD Code Example



```
#Kick
$InKickDistance + kick_threshhold:0.1
    "Yes" --> @KickBall
    "No" --> @GoToBallDirect

-->GoalieSimpleBehavior
$RoleDecision
    "goalie" --> $BallPositionKnown
        "No" --> @SearchBall
        "YES" --> $BallClose
            "Defend" --> $BallInOwnHalf
                "No" --> #PositionToBlockKick
                "Yes" --> #Kick
    "fieldplayer" --> [...]
        [...] --> #Kick
```

Conclusion

- no perfect solution
- depending on use case
- still a research topic

References

[1] Shakey the robot. [Online]. Available: https://en.wikipedia.org/wiki/Shakey_the_robot#/media/File:Shakey.png

[2] B. Siciliano and O. Khatib, *Springer Handbook of Robotics*, ser. Springer Handbook of Robotics. Springer Berlin Heidelberg, 2008. [Online]. Available: https://books.google.de/books?id=Xpgi5gSuBxsC

[3] Shakey the robot. [Online]. Available: https://en.wikipedia.org/wiki/Shakey_the_robot

[4] Event-driven finite state machine dsl in kotlin.

[5] M. B. Martin Poppinga, "Dsd - dynamic stack decider."

[6] J. R. Quinlan, "Induction of decision trees," *Machine learning*, vol. 1, no. 1, pp. 81–106, 1986.

References (cont.)

[7] M. Colledanchise and P. Ögren, "Behavior trees in robotics and ai: an introduction," *arXiv preprint arXiv:1709.00084*, 2017.

[8] behavior_tree. [Online]. Available: http://wiki.ros.org/behavior_tree

[9] R. E. Fikes and N. J. Nilsson, "Strips: A new approach to the application of theorem proving to problem solving," *Artificial intelligence*, vol. 2, no. 3-4, pp. 189–208, 1971.

[10] Stanford research institute problem solver. [Online]. Available: https://en.wikipedia.org/wiki/Stanford_Research_Institute_Problem_Solver