Artificial Intelligence and Robotics

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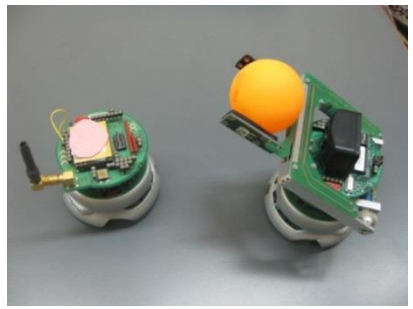
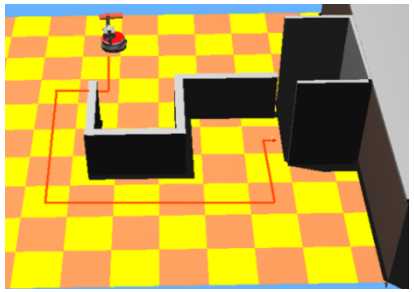
http://air.cs.itu.edu.tr

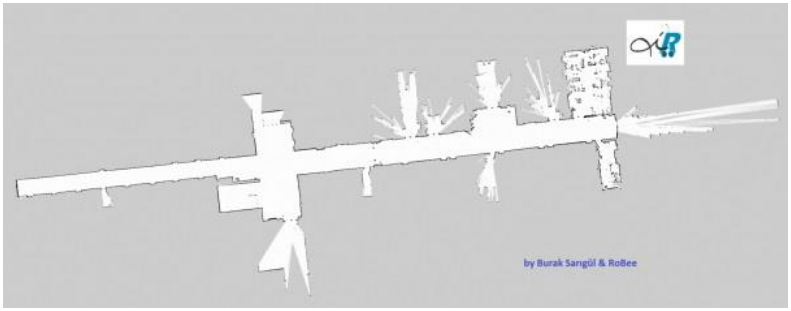
Funded by TÜBİTAK projects #111E-286, #115E-368 and #119E-436

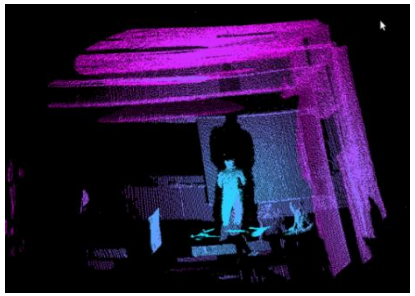
AIR Lab :: Main Research Areas

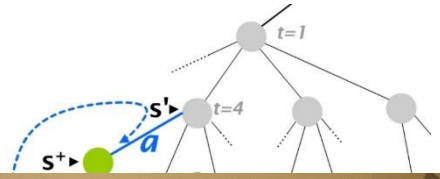
- Cognitive Robots
  - Environment and object Interactions
  - Automated reasoning
  - Automated planning
  - Learning
- Robot Intelligence

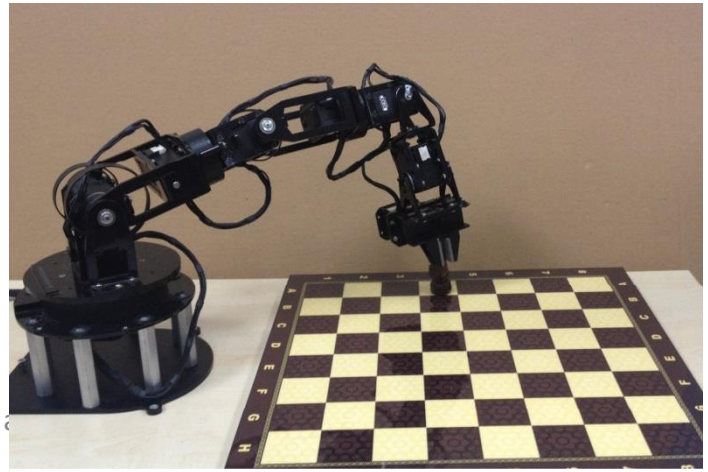


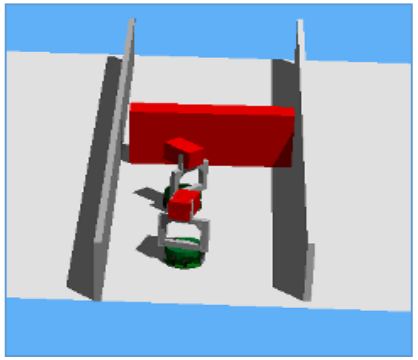






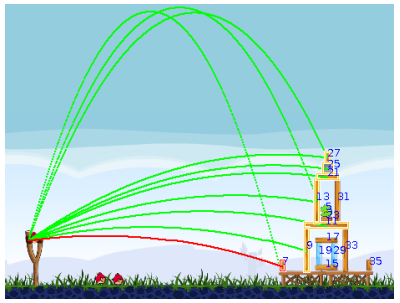


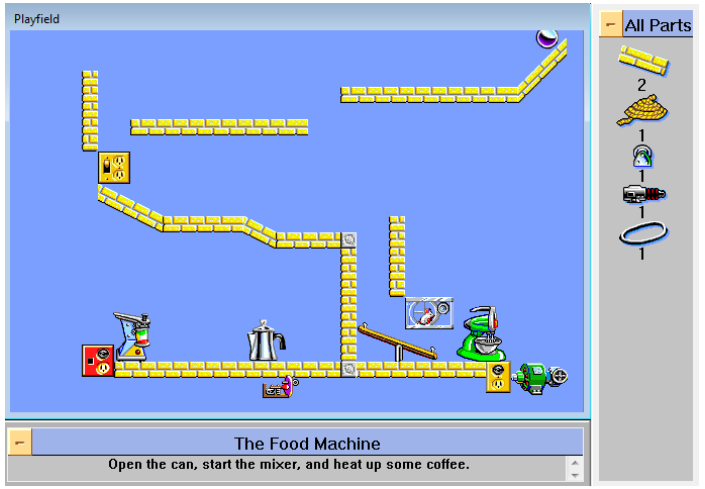




AIR Lab :: Main Research Areas

- Multirobot systems
  - Cooperative and competitive environments
- AI in Games
  - Player Profiling
  - Level design





What is intelligence?

- Defining intelligence by the properties it exhibits:
  - The ability
    - to solve problems
    - to answer questions and make new conclusions
    - to devise plans
    - to deal with new situations, and so on..

What is Artificial Intelligence?

- The scientific understanding of the mechanisms underlying thought and intelligent behavior; and their embodiment in machines.
  - The Association for the Advancement of Artificial Intelligence (AAAI)

- Artificial Intelligence is the study of systems that act in a way that to any observer would appear to be intelligent.

Why study AI?

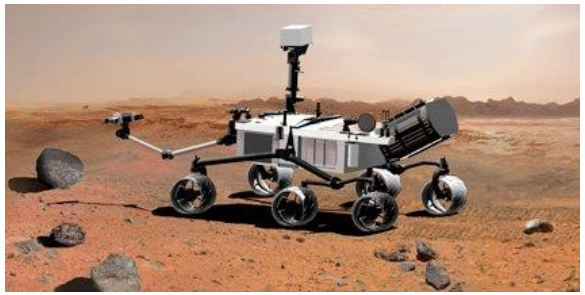
- Understand the nature of intelligence
- Make systems more effective
- Make systems easier for humans to work with
- Explore interesting intellectual questions
- Make money

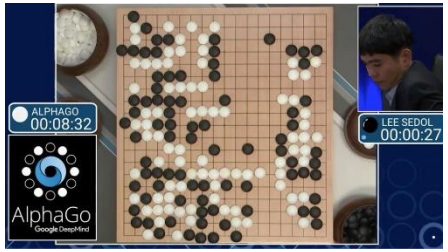
- Build intelligent systems

AI Applications in General

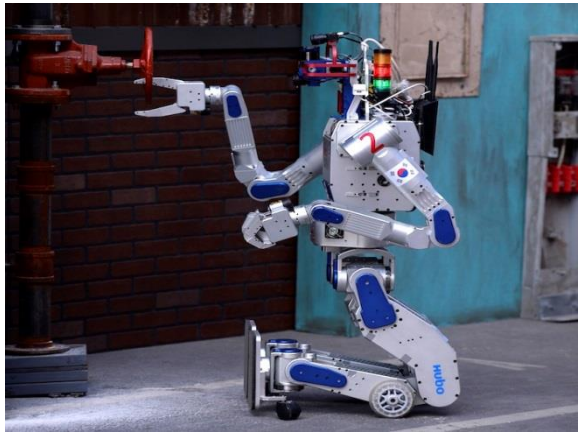








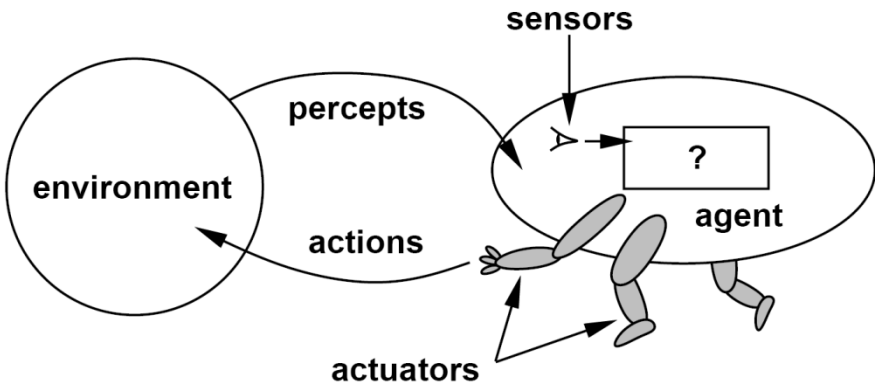


Cognition-Enabled Robot Manipulation in Human Environments: Requirements, Recent Work, and Open Problems , Mustafa Ersen, Erhan Öztop and Sanem Sariel**, IEEE Robotics & Automation Magazine, 2017**, vol. 27, no. 3, pp. 108- 122

Robots

A programmable mechanical device that operates in the real world where it takes input from its sensors and takes actions with its actuators.



$$f : \mathcal{P}^* \rightarrow \mathcal{A}$$

Basic Mobile Robot Problems

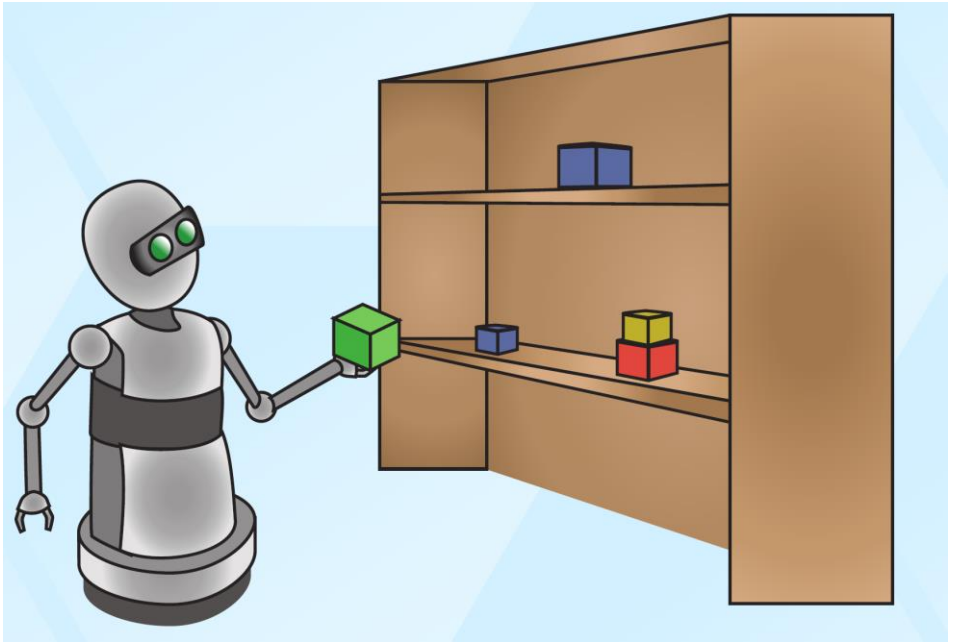
- Where am I? (localization)
- Where do I want to go? What is the environment like? (mapping)
- How do I get there? (planning)

Basic Service Robot Problems

- What is my goal? (Goal Selection)
- In which room am I in? (Semantic Mapping)
- Which tools and objects do I have?

(Scene Modelling)

- To achieve my goals:
  - What is the plan? (symbolic planning)
  - Which resources should I use? (scheduling)



- Are there any anomalies in the scene? Is everything all right? (Action and Plan Monitoring)
- What should I learn from my experiences? (Learning)
- Should I interact with others? (Human-robot, Robot-robot interactions)

Ethics in AI and Robotics

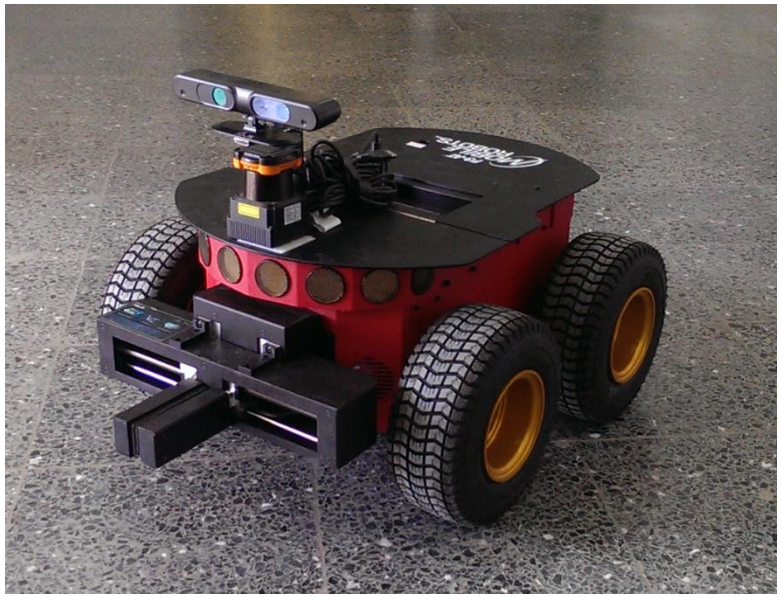
- IEEE Robotics and Automation Society
  - Roboethics Technical Group (2004)
- IEEE launched an initiative on ethics of autonomous systems
- Special issue of IEEE Robotics and Automation Magazine: March 2011: Roboethics
- The European Union funded several projects:
  - ETHICBOTS
  - ROboLaw

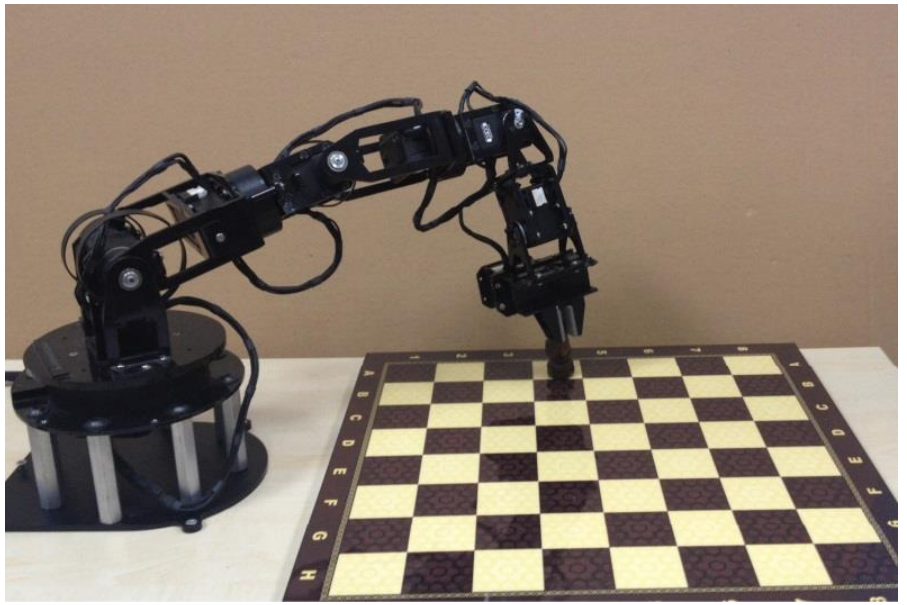
*Ethics in Robotics Research, Grinbaum et al, IEEE Robotics and Automation Magazine, 2017

Ethical concerns

- The military use of robots
- The use of autonomous weapons
- Ethical decision making for autonomous robots
  - Authority sharing
  - When and how should the operator take over the control?
- Respect for Privacy
- Safety

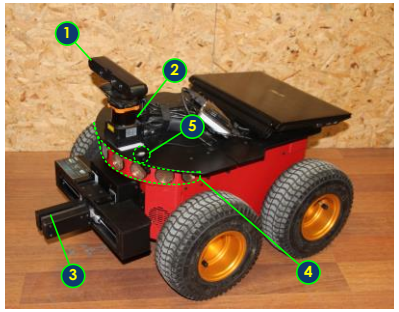
Our robots



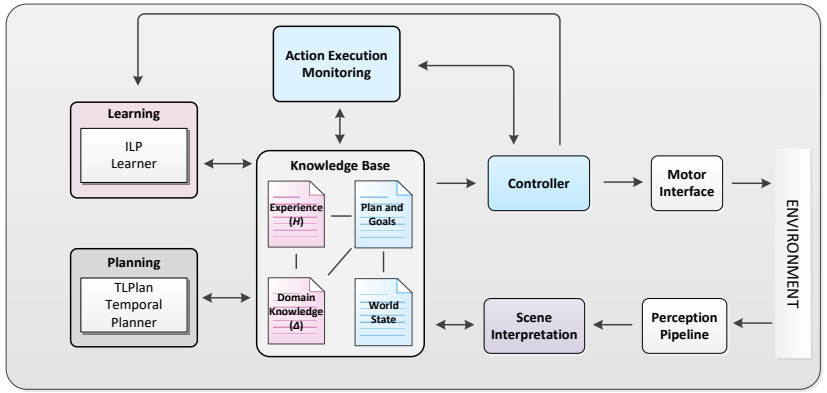


Our humanoid robot

A Generic Architecture for Safe Cognitive Robots



① ASUS Xtion PRO RGB-D Camera ③ Tactile Sensors inside the Gripper
② Hokuyo UTM-30LX Laser Rangefinder ④ Forward-facing Sonar Sensors (8 pieces)
⑤ SONY ECMC115 Clip Microphone

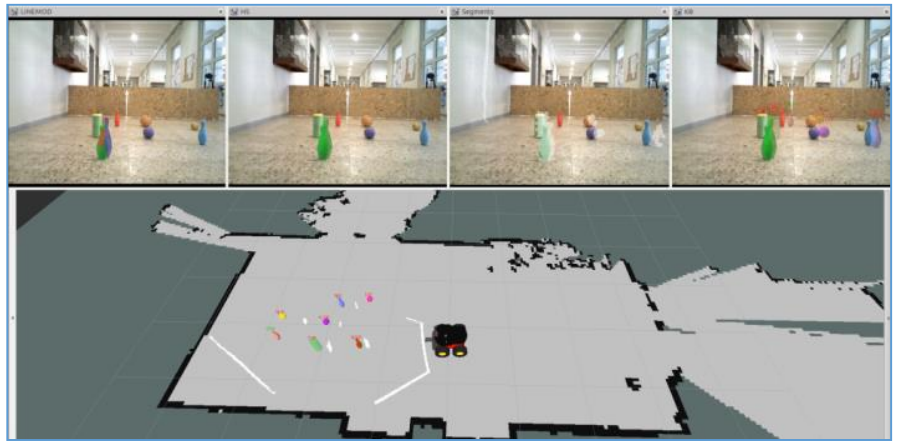


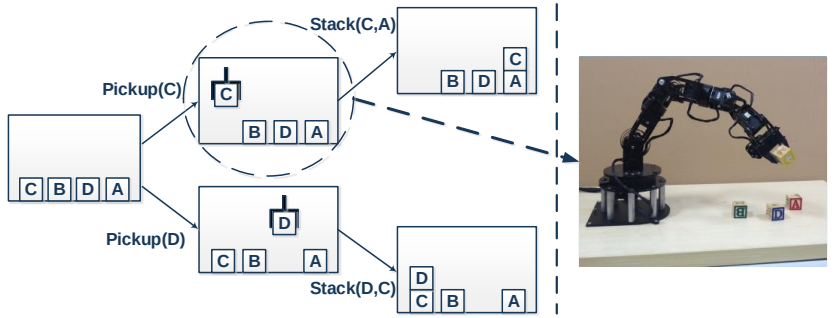
TÜBİTAK project # 111E-286 «Gezgin Robotlar Tarafından Eylem Temsillerinin Öğrenilmesi ve Dinamik Planlama Yapılması»

Cognitive robots learning failure contexts through real-world experimentation, Sertac Karapinar and Sanem Sariel, **Autonomous Robots**, Special Issue on Constrained Decision Making in Robotics, Vol. 39, No. 4, 2015, pp. 469-485

Motivation Video

Scene Interpretation

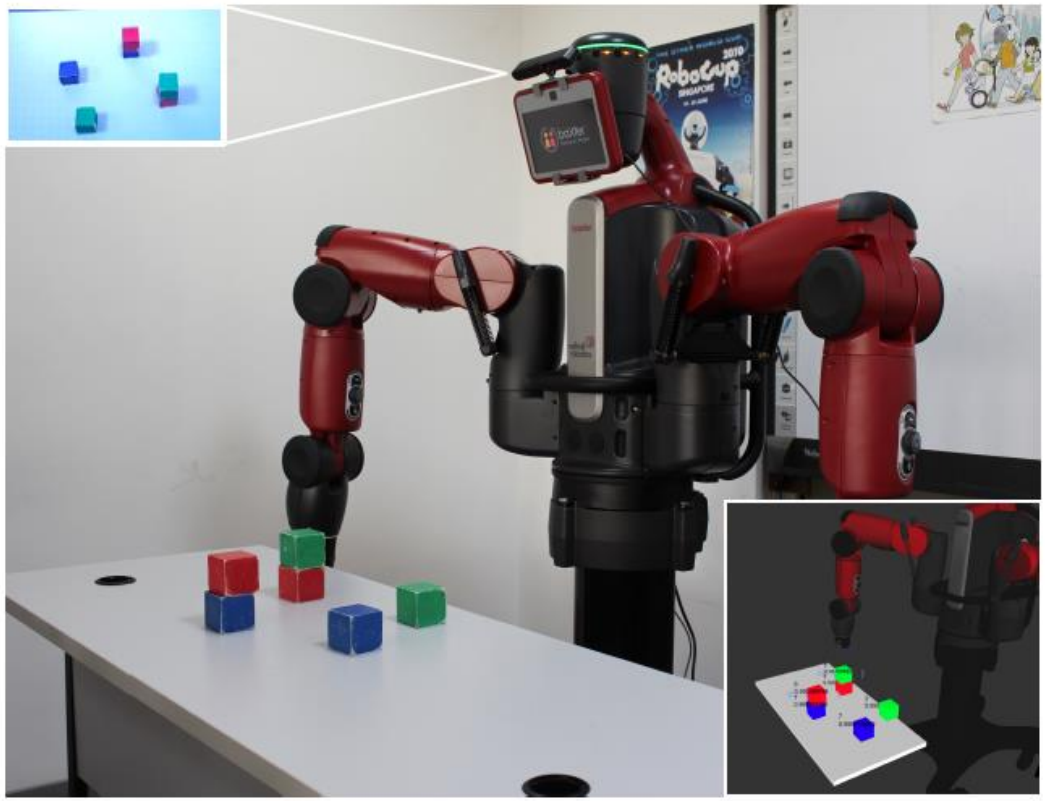


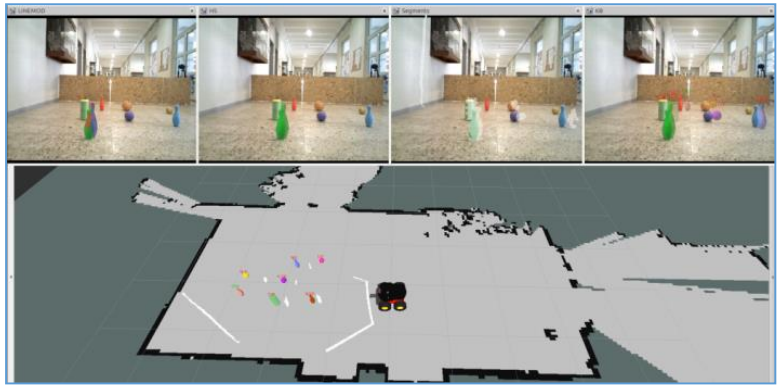


Continuous Visual World Modeling for Autonomous Robot Manipulation, Arda Inceoglu, Cagatay Koc, Besim Ongun Kanat, Mustafa Ersen, Sanem Sariel**, IEEE Transactions on Systems, Man, and Cybernetics: Systems, Vol. 49, No. 1, 2019, pp. 192 - 205**

http://air.cs.itu.edu.tr/projects/violet

Violet :: Visual Interpreter & MOdeLler for ObjEcts and RelaTions

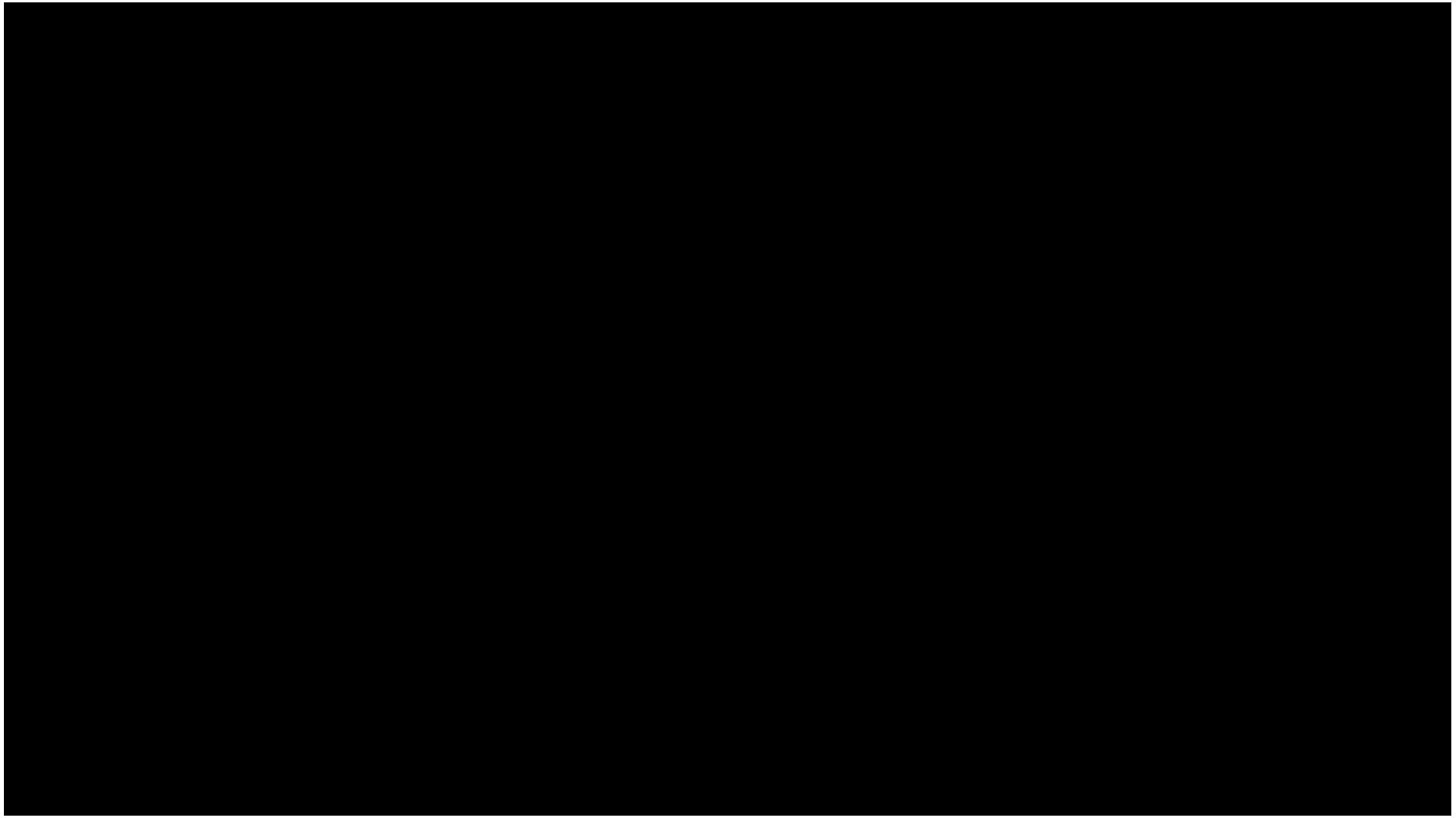




- A Bayesian Sensor Fusion System to Interpret Scenes

http://air.cs.itu.edu.tr/projects/violet

Violet Video



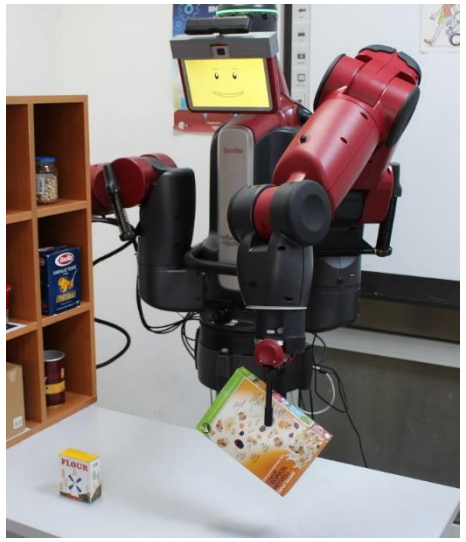
Failure Detection in Manipulation Actions

Execution monitoring is necessary for robots to safely interact with their environments.

- Sensory noise, hardware limitations, external factors, etc.
- Detecting, isolating and recovering from failures

Approach:

- Binary classification problem (success, failure)
- Extract high level predicates from modalities
  - Proprioception, Audition, Vision
- Evaluated on pick, place and push tasks

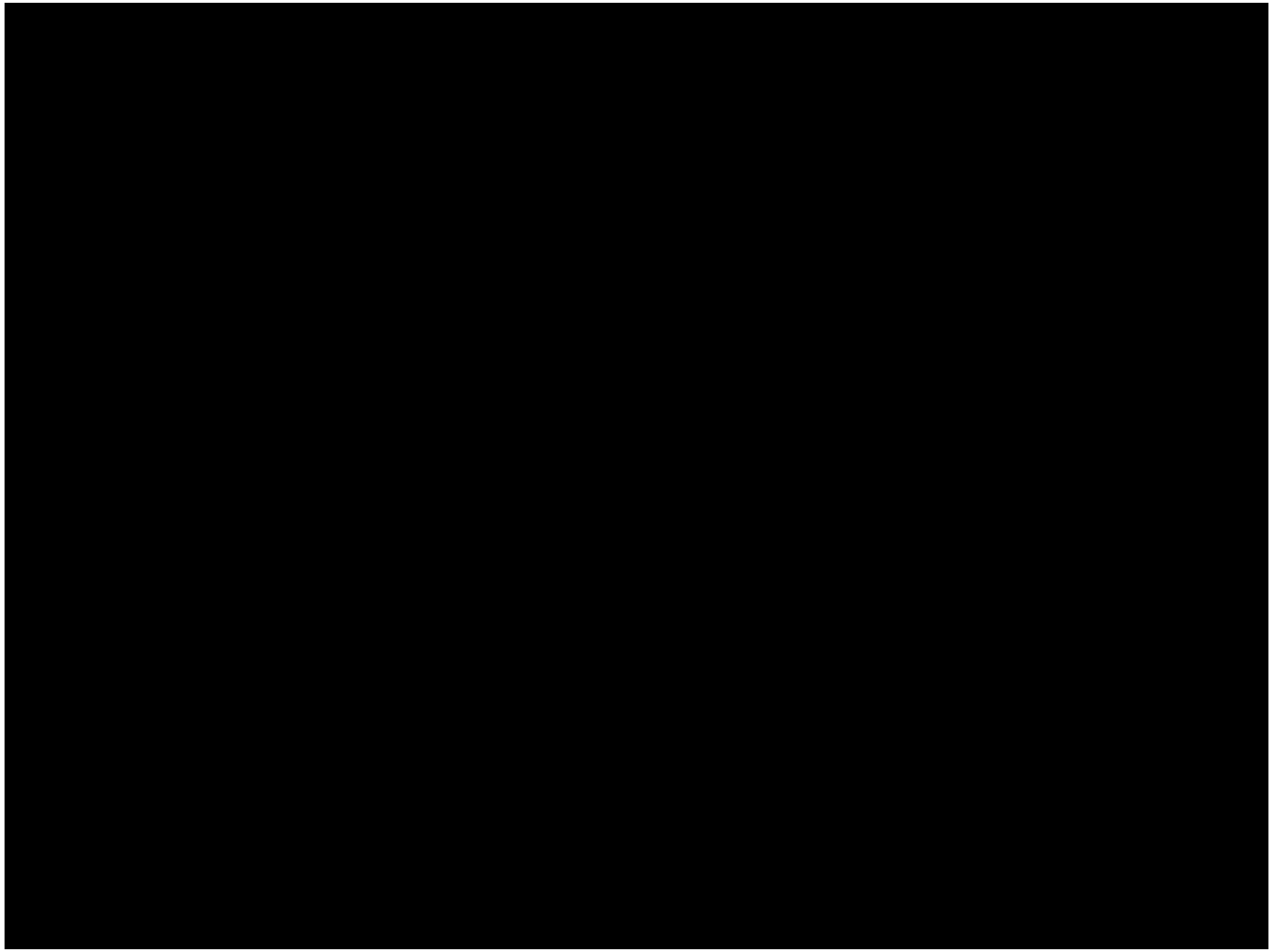


- TÜBİTAK project # 115E-368

- Failure Detection Using Proprioceptive, Auditory and Visual Modalities, Arda Inceoglu, Gokhan Ince, Yusuf Yaslan and Sanem Sariel**, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2018**

- Comparative Assessment of Sensing Modalities on Manipulation Failure Detection, Arda Inceoglu, Gokhan Ince, Yusuf Yaslan and Sanem Sariel**, ICRA Workshop on Multimodal Robot Perception, 2018**

Failure Detection Video



AI in Games

- Tight connection between AI and games
  - Most AI milestones are related to Games
  - We develop AI algorithms for playing games and making better games
  - We design games for developing new AI algorithms

- AI methods are applied in different forms depending on the game genre
  - Bot design for replacement of human players/opponents
  - NPC characters for better player interaction
  - Enhance player experience

Milestones in the History of AI in Games

- 1951 – Alan Turing reinvented the Minimax algorithm and used it to play Chess
- 1992 – TD-Gammon by IBM managed to play at a level of a top level human backgammon player
- 1994 – Chinook Checkers player won against the World Checkers Champion Marion Tinsley (Tinsley withdrew due to illness; it is solved by 2007)
- 1997 – IBM's Deep Blue beat Gary Kasparov
- 2017 – AlphaGo won Ke Jie in the game Go (The last board game where computers reached super-human performance)

Chess

- Deep Blue, IBM, 1997

- Against Garry Kasparov
  - 1996, in 1997 – won
  - Massively parallel
  - P2SC-based system with 30-nodes
    - each node containing a 120 MHz P2SC microprocessor
    - Written in C and ran under the AIX OP.
    - Capable of evaluating 200 million positions per second
    - search to a depth of 14 moves, to a maximum of twenty or even more moves in some situations
- Komodo is one of the last champions
  - International Computer Chess Tournament

The Jeopardy!

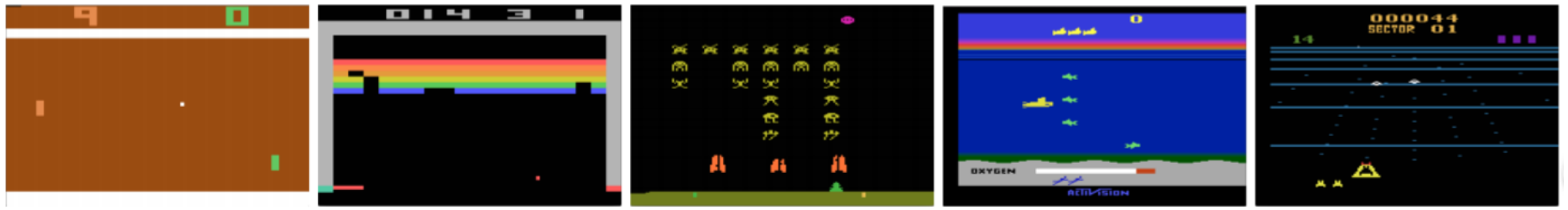
- Watson, IBM, 2011
- Beat humans in the TV game and quiz show: Jeopardy!
- Won 1 million USD

http://www.ibm.com

IBM Watson: The Science Behind an Answer: https://www.youtube.com/watch?v=DywO4zksfXw

Playing Atari with Deep RL

- Deep Q-network (DQN) agent, Google DeepMind, 2015
- input is raw pixels and output is a value function estimating future rewards.
- 49 Atari 2600 games from the Arcade Learning Environment, with no adjustment of the architecture or learning algorithm
- Hybrid Reward Architecture (HRA) is applied to Ms Pac-Man



Mnih et al, 2013

Go

Alpha Go, DeepMind, 2016

- learnt to play using thousands of human amateur and professional games

AlphaGo Zero, 2017

- learnt to play simply by playing games against itself, starting from completely random play

AlphaZero, could master a variety of games in just hours

https://deepmind.com/research/alphago/

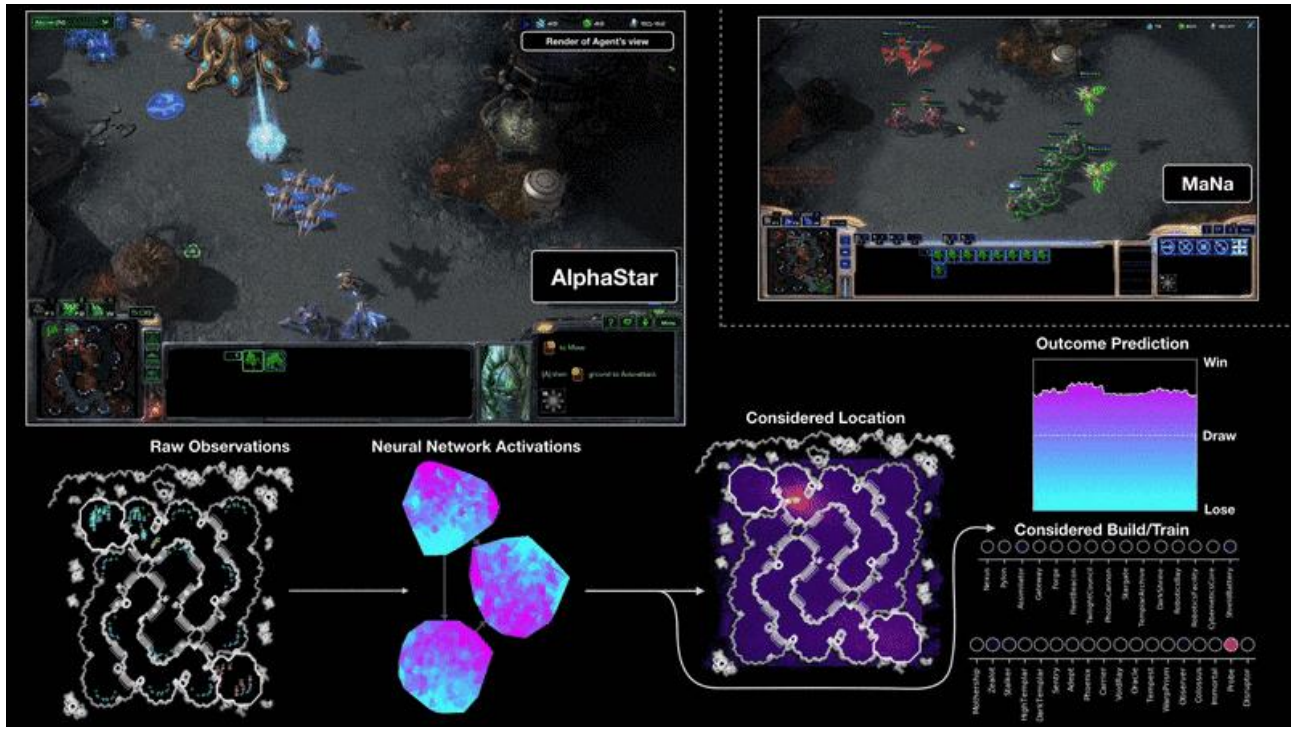
Dota 2

- OpenAI Five, OpenAI, August 2017
  - Played 180 *years* worth of Dota 2 against itself *every day* for about two months
  - LSTM and Reinforcement learning
  - Trained on a more simplistic one-to-one version of the game

teslerati.com

StarCraft II

- AlphaStar by DeepMind AI, Dec 19, 2018
  - Beat humans in 10/11 games against two professional human opponents
  - A deep neural network that is trained directly from raw game data by supervised learning and reinforcement learning

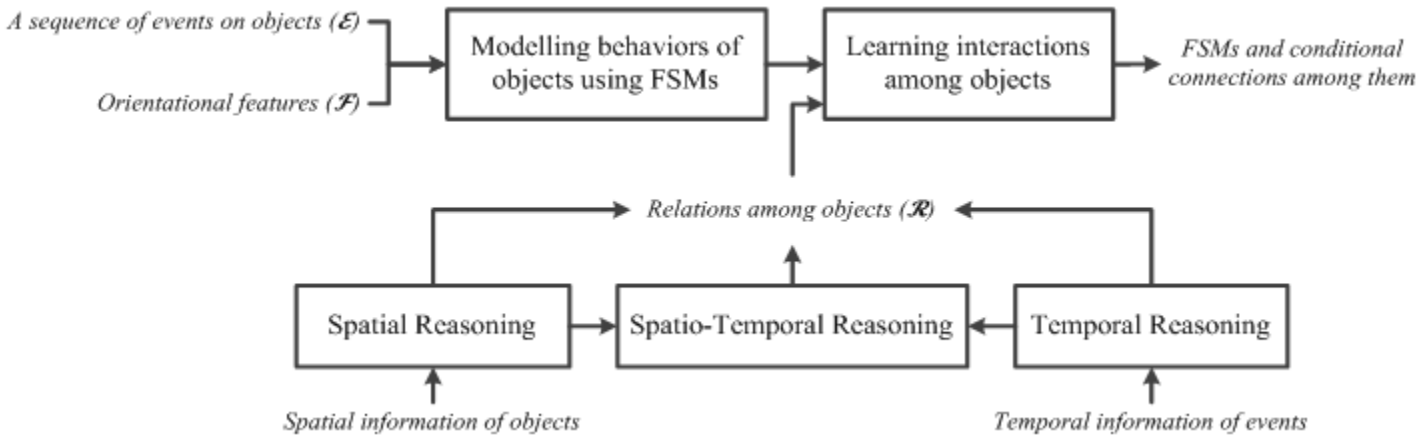


https://deepmind.com

The Incredible Machine Computer Game

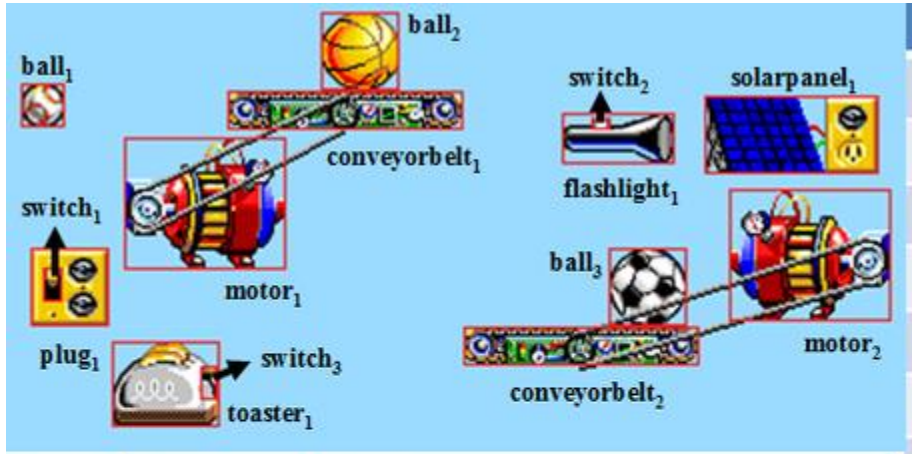
Reasoning for solving TIM

- Spatial Reasoning
- Temporal Reasoning
- Spatio-Temporal reasoning



Learning Behaviors of and Interactions Among Objects Through Spatio-Temporal Reasoning, Mustafa Ersen and Sanem Sariel, IEEE Transactions on Computational Intelligence and AI in Games, 2015, vol. 7, no. 1, pp. 75-87

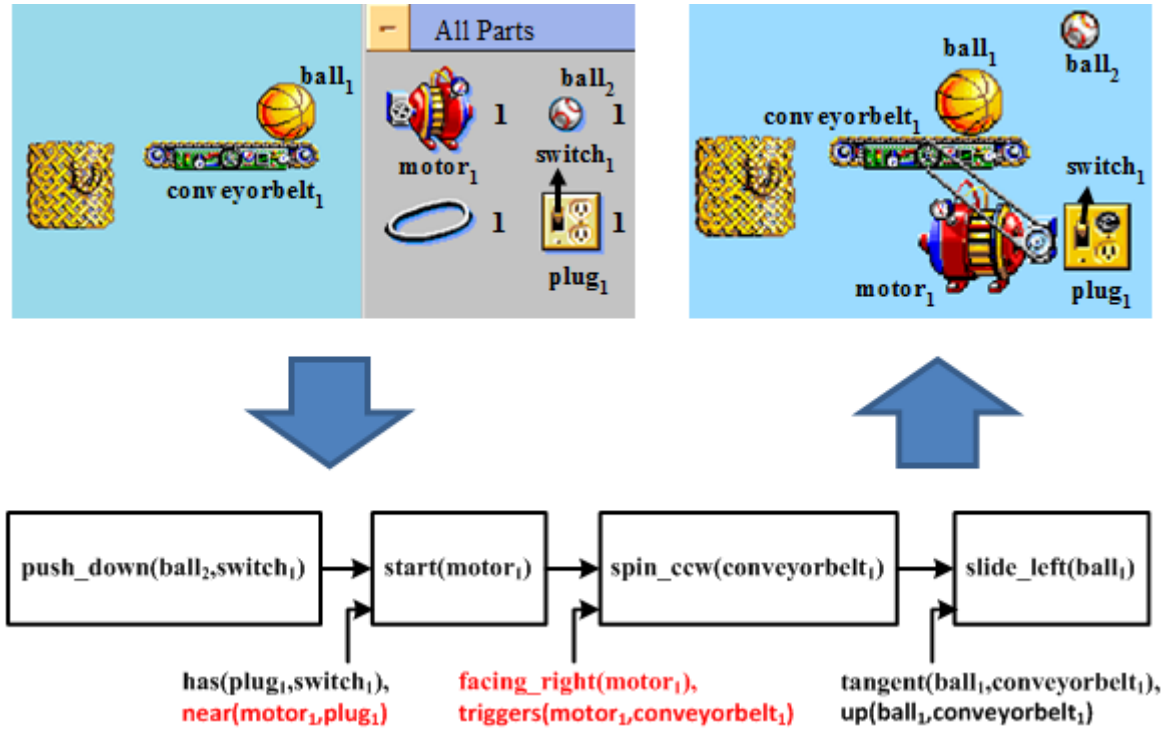
Reasoning for solving TIM



Index	Orientational Feature
F_1	facing_left(motor$_1$)
F_2	facing_right(motor$_2$)
F_3	facing_right(toaster$_1$)
F_4	facing_right(flashlight$_1$)

Index	Action	Timestamp
E_1	push_down(ball$_1$, switch$_1$)	5
E_2	start(motor$_1$)	6
E_3	spin_cw(conveyorbelt$_1$)	7
E_4	slide_right(ball$_2$)	8
E_5	press(ball$_2$, switch$_2$)	10
E_6	light(flashlight$_1$)	11
E_7	charge(solarpanel$_1$)	12
E_8	start(motor$_2$)	13
E_9	spin_ccw(conveyorbelt$_2$)	14
E_{10}	slide_left(ball$_3$)	15
E_{11}	push(ball$_3$, switch$_3$)	20
E_{12}	make_toast(toaster$_1$)	25

Solving TIM


All Parts
ball1
conveyorbelt1
motor1
ball2
switch1
plug1
1
push_down(ball2,switch1)
start(motor1)
spin_ccw(conveyorbelt1)
slide_left(ball1)
has(plug1,switch1),
near(motor1,plug1)
facing_right(motor1),
triggers(motor1,conveyorbelt1)
tangent(ball1,conveyorbelt1),
up(ball1,conveyorbelt1)

User Profiling in Games

- Modeling player profiles
- Machine Learning methods for classifying user traits:
  - explorer, competitor, hoarder, strategist, social or exploiter
- Churn analysis

Dusk Racer

WoW

A Generic Approach for Player Modeling Using Event-Trait Mapping Supported by PCA, Mehmet Akif Gunes, Mehmet Fatih Kavum and Sanem Sariel, ***Proceedings of the Advances in Computer Games, 2021***

A Generic Approach for Player Modeling using Event-Trait Mapping and Feature Weighting, Mehmet Akif Gunes, Gokhan Solak, Omer Erden, Ugur Akin and Sanem Sariel, ***The Twelfth Annual AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment, San Francisco, USA, 2016***

Bots for Starcraft

Level Design for Games

- Extended the level design mechanisms by LSTMs [Summerville and Mateas 2016]

RoboCup

- RoboCup : The Robot World Championship 1992-...
- The ultimate goal of the RoboCup project is:

  by 2050, develop a team of fully autonomous humanoid robots that can win against the human world champion team in soccer.

RoboCup


Darmstadt Dribblers 07
BotSport
21:21
01 FUmanoids
RoboCup Soccer Humanoid League
KidSize category

RoboCup:: Leagues

RoboCupSoccer

- Simulation League
  -2D, 3D, Mixed Reality
- Small Size Robot League
- Middle Size Robot League
- Four-Legged Robot League (-2007) > Standard Platform (2008-)
- Humanoid League (from 2002)
  - Kid-size, Teen-size

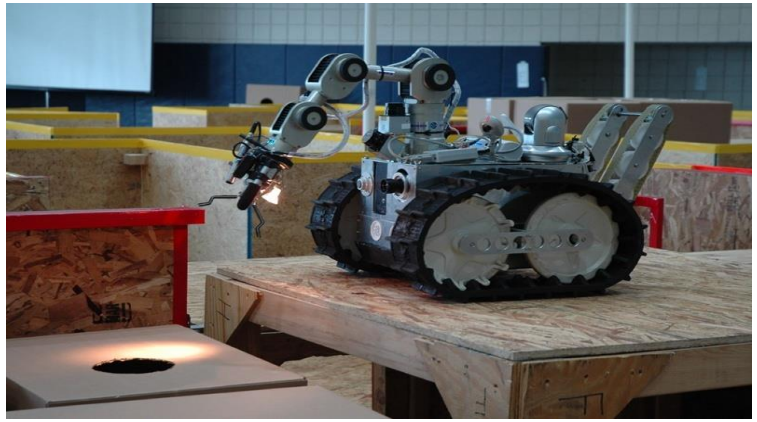
RoboCup:: Leagues

Exhibitions

- RoboCup Commentator Exhibition

RoboCupRescue

- Rescue Simulation League
- Rescue Robot League

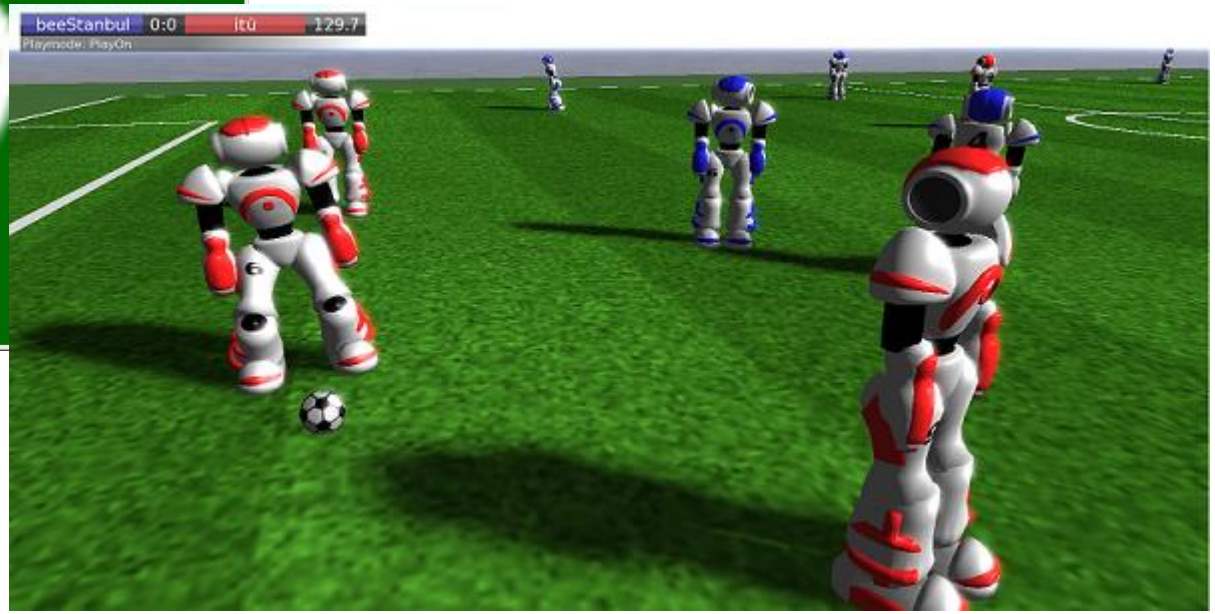


RoboCup@Home (since 2006 –)

RoboCupJunior

- Soccer Challenge
- Dance Challenge
- Rescue Challenge

RoboCup 3D Soccer Simulation League



Thanks

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