



# CONSTRUCTING AUTONOMOUS AGENTS USING THE COGNITIVE-EMOTIONAL ARCHITECTURE OF THE MIND

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Z. Kowalczyk and M. Czubenko

Gdańsk University of Technology

Faculty of Electronics, Telecommunications and Informatics

Department of Decision Systems and Robotics



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# Reasons for Brain Modeling

## Philosophical

- How do we perceive?
- How are we focusing?
- How do we remember?
- How do we think?
- Why do we think?



# Artificial Intelligence

## Cybernetic

- Imitation of real systems
- Various tools

## Statistic

- Statistical modeling
- Sophisticated tools

## Symbolic (syntetic)

- functions of AI  
(GA, FUZ, EXP; TDU, Bbox)
- high-level modeling,  
large/imprecise structures

## Sub-symbolic (embodied)

- defined tasks/answers  
(ANN, AssN; BUA, B/Wbox)
- self-training structures,  
small structures



# Definitions

## Intelligence

Intelligence is the ability of active processing of cognitive information in order to adapt to the changing environment and to gain own, specific purposes or common goals

## Embodiment

Mechanism under the control of an intelligence core that contains sensors and actuators connected with this core via communication channels

## Cognitive Science - Embodied Intelligence

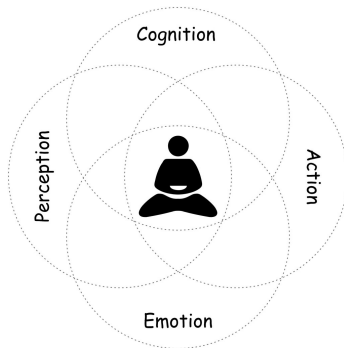
Higher intelligence also needs aspects of the body (movement, perception and visualization)



# Mind Functioning

## Aspects of modeling

- Perception
- Objects recognition
- Motivation
- Representation & memory
- Virtual imagination
- Behavior & planning



# Decision-making Paths

## Classical

- Optimization
- Well-defined problems

## Cognitive

- Finding a solution for real problems
- Uncertainty, risks, social aspects



# Artificial Decision-making Systems

## General concepts of motivation

- 1 Behavior-based
- 2 Beliefs-Desires-Intentions
- 3 Emotional
- 4 Needs driven
- 5 Cognitive – hybrid: (3) & (4)





# Combination of Psychological Models in ISD

## Cognitive Aspects

- the way of processing the information
- from stimuli to reaction

## Motivation theory: identify the problem & seek solutions

- (fuzzy system of) needs
- (rainbow of) emotions



# Sensory Perception



## Sequence of operation

- getting stimuli
- first-level of filtering
- writing information to ultra-short time memory

# Higher perceptions

## Impressions

- recognizes impressions (lines, color, texture, sounds, odors, ...)
- filters impressions (the second level of filtration)

## Discovery perception

- converts impressions to discoveries (objects, observations)
- compares unrecognised discoveries to the memorized discoveries
- creates new discoveries



# Attention: data filtering & resource management

## Unconscious

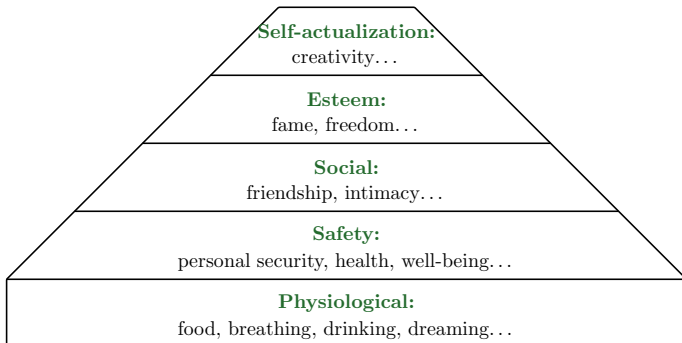
- filters discoveries
- administers cognitive resources (actuators)
- analyses and memorizes discoveries

## Conscious

- controls perception
- names new discoveries



# Fuzzy Needs in Maslow's Pyramid



# ISD Emotions Theory (eRainbow)



# ISD Emotions I

## Division by culture

- classic emotion – generalized (predefined, common emotions)
- equalia – personal emotion (undefined, abstract, private emotions)



# ISD Emotions II

## Division by time

- sub-emotion (short time)  
based on discoveries from memory (eg.. joy of having a teddy bear)
- emotion (average time)  
created from the states of needs and sub-emotions
- mood (long time)  
based on a ('derivative') TAWS mechanism

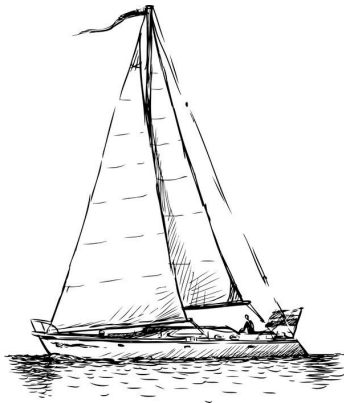




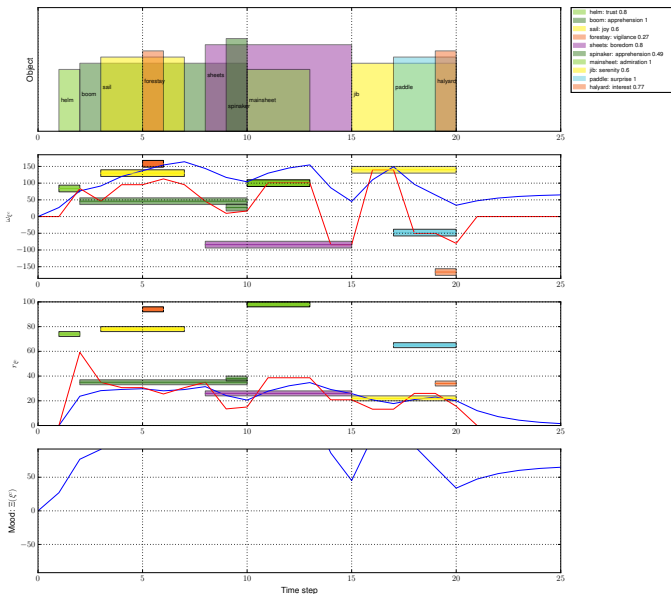
# eSailor's Emotional Discoveries

## Objects in agents attention

- tiller (helm): trust
- boom: apprehension
- sail: joy
- forestay: vigilance
- sheets: boredom
- spinnaker: apprehension
- mainsail: admiration
- jib: serenity
- paddle: surprise
- halyard: interest



## eSailor's Emotion Mood Evolution



# eDriver: Scenario Elements

**Table:** The scenario of a simulation study.

Distance [km]	Scenario element
0.1	recommended speed 90 km/h
1.0	recommended speed 50 km/h
1.2	zebra sign
1.4	zebra
1.6	cancel of 50 km/h
2.8	recommended speed 30 km/h
3.2	left lane order
3.4	road narrows
3.8	end of road narrows
4.6	right lane order
4.8	cancel of 30 km/h
4.9	pedestrian on the road



# xDriver Needs

## Level of Maslow class: need

- physiological/principal level: energy optimization
- physiological level: goal achievement
- safety level: security of car
- safety level: traffic regulations
- (self-)esteem level: speed
- (self-)esteem level: confidence
- self-actualization level: creativity.



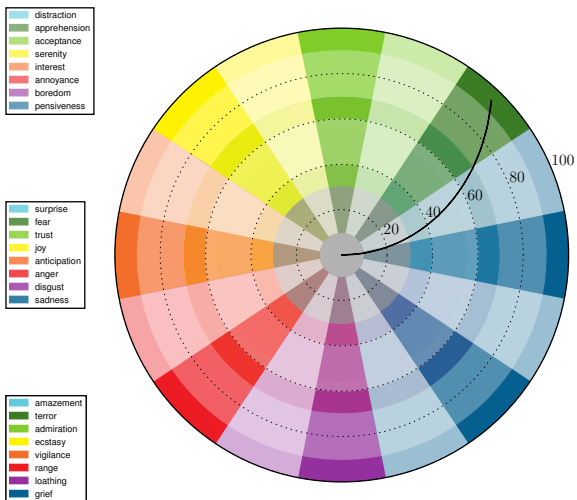
# xDriver Reactions

**Table:** Reactions of the xDriver agent.

Distance [km]	xDriver reaction	xDriver emotion
0.00	increment speed to value: 90	indifference
0.66	brake to value: 50	indifference
0.79	keep current speed value: 0	indifference
0.85	increment speed to value: 50	indifference
1.06	brake to value: 50	indifference
1.09	keep current speed value: 0	indifference
1.26	increment speed to value: 90	indifference
2.09	keep current speed value: 0	indifference
2.45	brake to value: 30	indifference
2.62	keep current speed value: 0	indifference
3.25	keep current speed value: 0	indifference
4.45	increment speed to value: 90	indifference
4.61	increment speed to value: 90	distraction
4.63	emergency brake value: 0	surprise
4.63	emergency brake value: 0	fear
4.65	emergency brake value: 0	terror
4.85	keep current speed value: 0	terror
4.85	keep current speed value: 0	fear
4.85	keep current speed value: 0	surprise
4.85	keep current speed value: 0	distraction
4.85	increment speed to value: 90	indifference
5.65	keep current speed value: 0	indifference



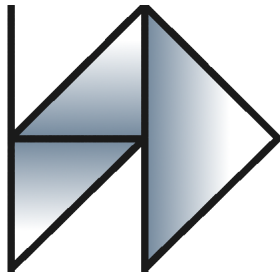
## eRainbow Evolution of xDriver's Emotion



# ISD Applications

## Possibilities

- embedded control system of autonomous robots (eg. guardians)
- control system of groups of robots
- engine of chatterbot
- modelling human behaviour



# The Literature

## Publisher: *Title* (link)

- AMCS: *Intelligent decision-making system for autonomous robots*  
(<https://content.sciendo.com/view/journals/amcs/21/4/article-p671.xml>)
- Cognitive Computation: *Autonomous driver based on an intelligent system of decision-making*  
(<https://link.springer.com/article/10.1007/s12559-015-9320-5>)
- IFAC: *Emotions embodied in the SVC of an autonomous driver system*  
(<https://www.sciencedirect.com/science/article/pii/S2405896317309448>)
- FRAI: *Computational approaches to modeling artificial emotion—an overview of the proposed solutions*  
(<https://www.frontiersin.org/articles/10.3389/frobt.2016.00021/full>)





# The End

THANK YOU FOR YOUR ATTENTION

