In the name of the absolute power and the absolute knowledge

Social and Cognitive Robotics

Chapter 2: **Design and interaction of social robots**

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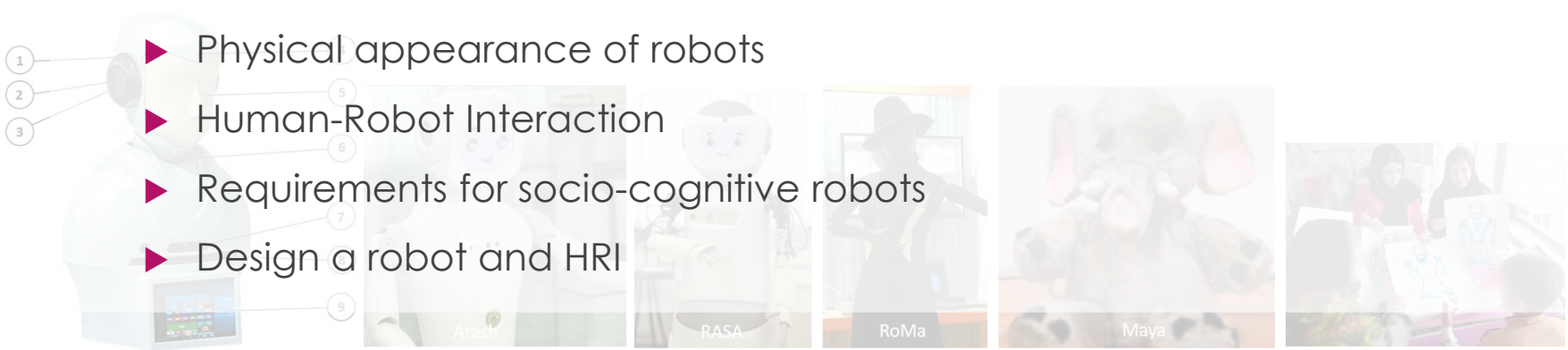
Outlines

- Introduction, definitions, and basic concepts
- *Chapter 2:* **Design and interaction of social robots**
- Design and interaction perspective of social robots
  - How a robot works
  - Common Approach in Social Robotics
  - Physical appearance of robots
  - Human-Robot Interaction
  - Requirements for socio-cognitive robots
  - Design a robot and HRI



itive Robots; wrap up

Previously …

رویای من اینه …

- ربات های اجتماعی و شناختی، ربات هایی هستند که برای تعامل با انسان ها و یا با یکدیگر طراحی می شوند و در تعاملات انسانی، تقریباً مشابه انسان ها عمل می کنند.
- هدف از طراحی و ساخت ربات های اجتماعی و شناختی و تعامل آن ها با انسان، ایجاد هم افزایی در سیستم های ترکیبی انسان-ربات است.
- قرار نیست تا این ربات ها جایگزین انسان ها شوند؛ بلکه آنها با توانایی های خود، قدرت اجتماعی و شناختی انسان ها را افزایش می دهند.
- این ربات ها دارای حافظه از مشاهدات و تجربیات خود در زمان های مختلف بوده، صریحاً با یکدیگر تعامل داشته و از هم می آموزند.
- این حوزه تحقیقاتی (به شدت) بین رشته ای بوده و تخصص های مختلف در آن درگیر می باشند (مهندسین مکانیک، کامپیوتر، برق، روانشناسان، متخصصین علوم شناختی، زبان شناسان، فلاسفه و ...).

How a Robot Works

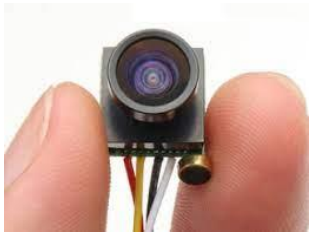
- For students who have limited technical background about intelligent interactive robotics, it is good to start with
  - the basic hardware and software components that a robot consists of;
  - the techniques we can apply to make a robot ready for interacting with people.

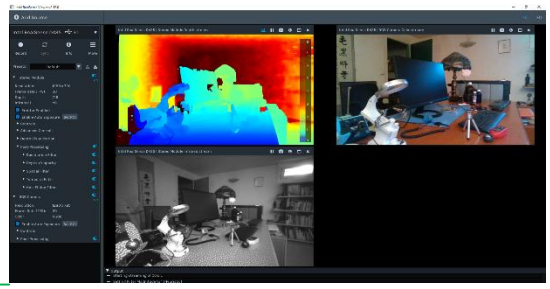
Let's start …

How a Robot Works *(cont.)*

a Robot is an Entity that can Sense, Think, and Act.

- Robots' main elements
  - Sensors *(RGB-D Camera, Microphone, Tactile Sensors, IMU, Position and/or Proximity Sensors, LIDAR, etc.)*
  - Processors and Internal Computers
  - Actuators *(Motors, Speakers, LEDs, Pneumatic actuators, etc.)*





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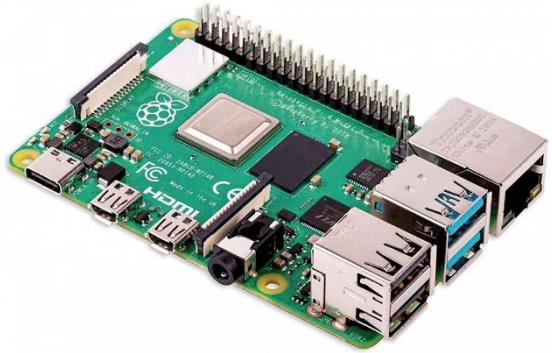

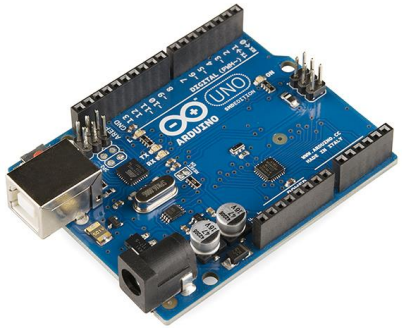

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How a Robot Works; *Some basic questions*

- Typical problems that robot engineers have to solve for the robot include the following
  - What kind of body does the robot have? Does it have wheels? Does it have arms?
  - How will the robot know its location in space?
  - How does the robot control and position its body part; for example, arms, legs, wheels?
  - What does the space around the robot look like? Are there obstacles, cliffs, doors? What does the robot need to be able to perceive about this environment to move safely?
  - What are the robot's goals? How does it know when it has achieved them?
  - Are there people around? If so, where are they, and who are they?
  - How will the robot know?
  - Is a person looking at the robot? Is someone talking to it? If so, what does the robot understand from these cues?
  - What is the human trying to do? What does the person want the robot to do? How can we make sure the robot understands this?
  - What should the robot do, and how should the robot react?

چند سال پیش، خبری روی خبرگزاری ها پدیدار شد مبنی بر این که ژاپنی ها یک ربات را در مهدکودک ثبت نام کرده اند!! به نظر شما یک ربات اجتماعی و شناختی تمام عیار، چه ویژگی هایی باید داشته باشد؟

Common Approach in Social Robotics

رویکرد متداول در حوزه رباتیک اجتماعی

شناسایی یک نیاز در جامعه (عمدتا برای کودکان)

Design and Fabrication	Control and Machine Learning	Clinical Interventions
خرید، و یا طراحی و ساخت ربات های اجتماعی- شناختی با توجه به نیازهای مورد نظر	پیاده سازی الگوریتم های کنترلی و هوش مصنوعی جهت توانمندسازی ربات ها برای نیل به اهداف تعیین شده	انجام مطالعات میدانی و مداخلات بالینی در حوزه بررسی مقبولیت، آموزش، توانبخشی و ...

Common Approach in Social Robotics

رویکرد متداول در حوزه رباتیک اجتماعی

شناسایی یک نیاز در جامعه (عمدتا برای کودکان)

- **Physical appearance of robots**
- **Human-Robot Interaction**
- **Evaluation of interventions** *(will be studied later)*

Clinical Interventions

Control and Machine Learning

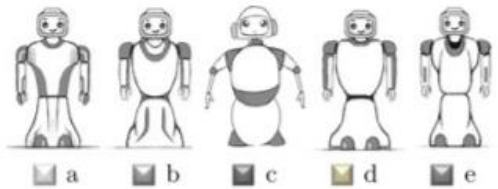
Design and Fabrication

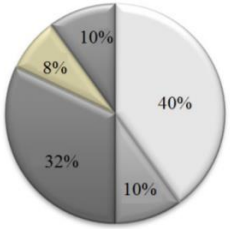
Physical appearance of robots

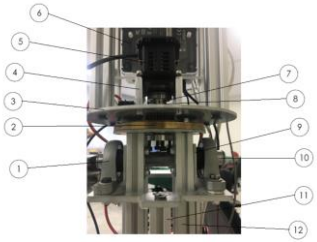
- A person interacting with a robot is struck first by the robot's physical appearance.
- There is little consistency in physical appearance of social robots;
  - has ranged across many levels of anthropomorphism, *including humanoid, animal-like, cartoon-like*, and machinelike (nonbiomimetic) systems.
  - stylized features to a realistic and/or complex appearance.
  - Various Degrees of Freedom (DoF)

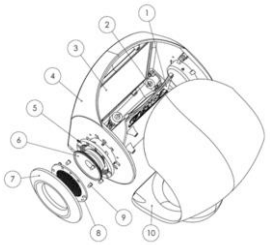
Physical appearance of robots

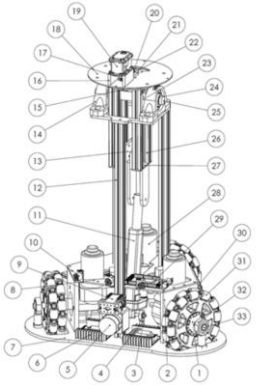
Arash-I: A social robot buddy to support children with cancer in a hospital environment

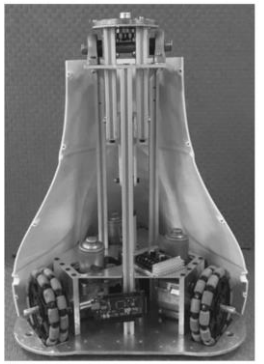






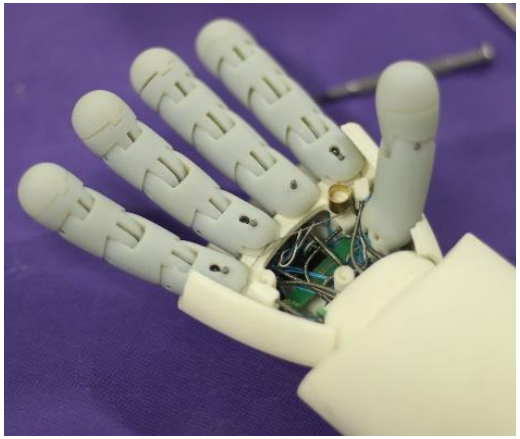


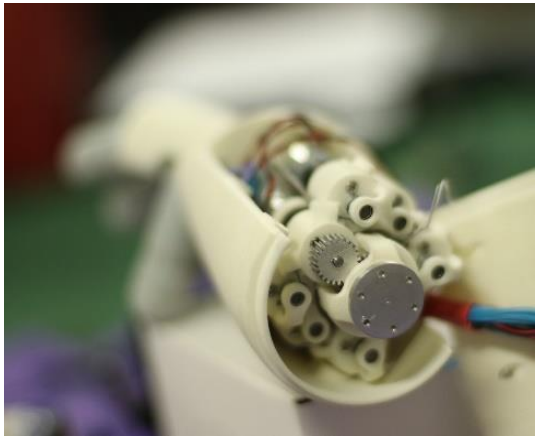


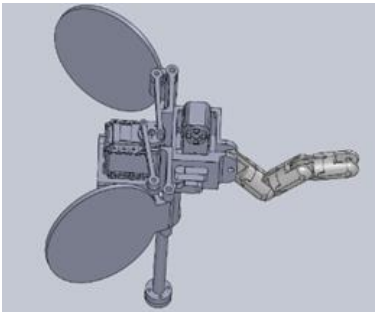


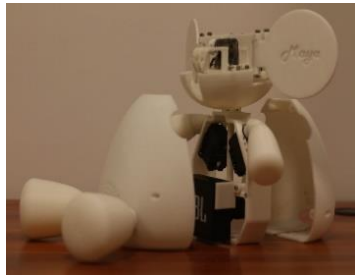
Physical appearance of robots

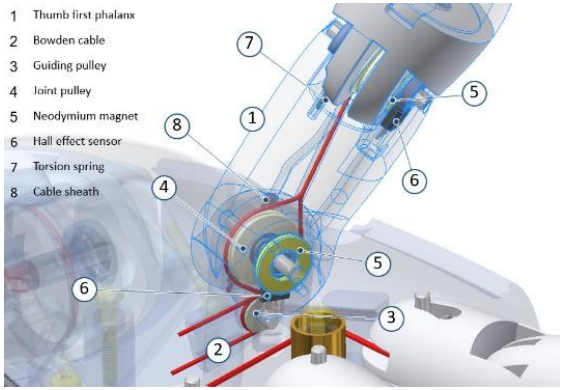
Robot Design

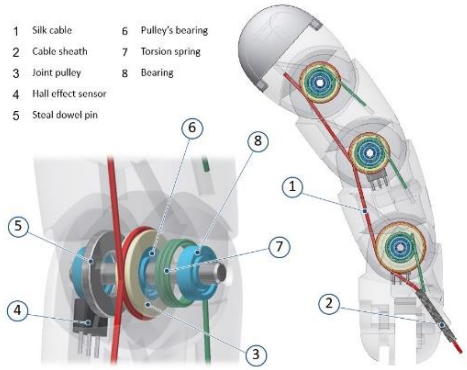








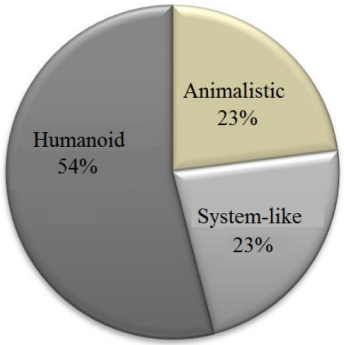


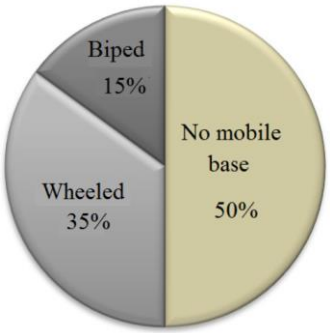


Physical appearance of robots

A survey on social Robots' DoF

Number	Robot name	Grasping ability	Degrees of freedom					
			Face	Neck	Arm × 2	Waist	Platform	SUM
(1)	Leonardo	Yes	32					69
(2)	ASIMO	Yes	0	3	40	2	12	57
(3)	iCub	Yes	3	3	32	3	12	53
(4)	Flash	Yes	8	3	38	0	3	52
(5)	REEM-C	Yes	0	2	28	2	12	44
(6)	Nexi	Yes	15	4	18	0	4	41
(7)	Simon	Yes	9	4	22	2	0	37
(8)	FACE	No			0	0	0	32
(9)	Care-o-bot 4	Yes	0	4	18	4	3	29
(10)	Infanoid	Yes	7	3	16	3	0	29
(11)	Nao	Yes	0	2	12	1	10	25
(12)	Amigo	Yes	0	2	16	1	3	22
(13)	**RIBA**	No	0	3	14	2	3	22
(14)	Kismet	No	18	3	0	0	0	21
(15)	Rh-1	No	0	1	8	0	12	21
(16)	Probo	No	18	3	0	0	0	21
(17)	Eddie	No	18	3	0	0	0	21
(18)	Miio	Yes	5	2	10	1	3	21
(19)	Pepper	No	0	2	12	3	3	20
(20)	Bandit	Yes	3	2	12	0	3	20
(21)	Kaspar	No	5	3	8	1	0	17
(22)	Dr. Araslh	No	0	2	8	2	3	15
(23)	Pleo	No	2	2	4	1	4	13
(24)	iCat	No	11	2	0	0	0	13
(25)	Huggable	No	2	3	6	1	0	12
(26)	Troy	No	0	2	8	0	0	10
(27)	Paro	No	2	2	4	0	0	8
(28)	Maggie	No	0	2	2	0	3	7
(29)	MonarCH	No	0	1	2	0	3	6
(30)	Robota	No	0	1	2	0	2	5
(31)	Gostai Jazz	No	0	2	0	0	3	5
(32)	Buddy	No	0	2	0	0	3	5
(33)	Iromec	No	0	1	1	0	3	5
(34)	Aisoy	No	2	2	0	0	0	4
(35)	Muu	No	2	2	0	0	0	4
(36)	Keepon	No	0	2	0	2	0	4
(37)	Tito	No	0	1	2	0	0	3
(38)	Leka	No	0	0	0	0	3	3
(39)	Romibo	No	0	0	0	0	3	3
(40)	Jibo	No	0	1	0	1	0	2





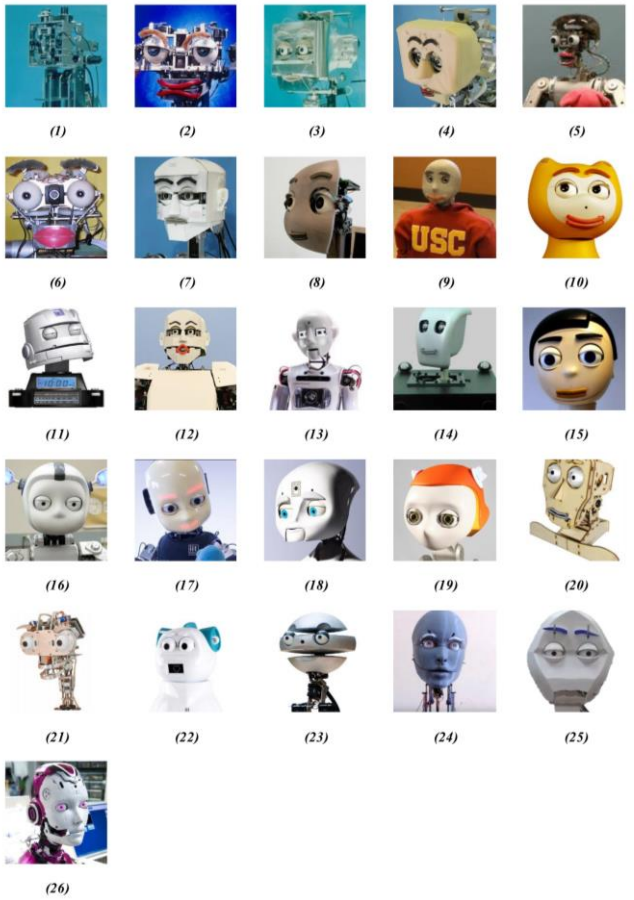
- **انواع سر و چهره های ربات های اجتماعی و شناختی:**
  - سر با اجزاء مکانیکی *(مکاترونیکی)*
  - استفاده از صفحه نمایش تخت *(تبلتی)*
  - پوست صورت با قابلیت ارتجاعی *(اندروید)*
  - شبیه سازی ظاهری برخی از عناصر ساده چهره
  - استفاده از پروژکتور جهت متحرک سازی و نمایش حالات چهره بر روی یک سطح نازک و نیمه شفاف

Physical appearance of robots

A survey on social Robots' DoF

سر با اجزاء مکانیکی

ردیف	نام ربات	سال تولید	تعداد درجات آزادی در سر و گردن
(1)	WE-2	1995	-
(2)	Kismet	1997	21
(3)	WE-3RII	1998	-
(4)	WE-3RV	2001	-
(5)	Infanoid	2001	8
(6)	Ayran	2003	8
(7)	WE-4R	2004	-
(8)	Mertz	2004	13
(9)	Bandit	2004	6
(10)	iCat	2005	14
(11)	Mr. Clock Radio	2007	-
(12)	Kobian	2009	10
(13)	RoboThespian	2009	-
(14)	Samuel	2010	15
(15)	Flobi	2010	18
(16)	Simon	2010	13
(17)	iCub	2011	6
(18)	Nexi	2011	21
(19)	S2 Humanoid	2012	7
(20)	Fritz	2013	13
(21)	Aisoy	2014	4
(22)	Muecas	2014	-
(23)	Flash	2015	10
(24)	Athena	2016	-
(25)	University of Tehran	2017	14
(26)	Alena	2017	6

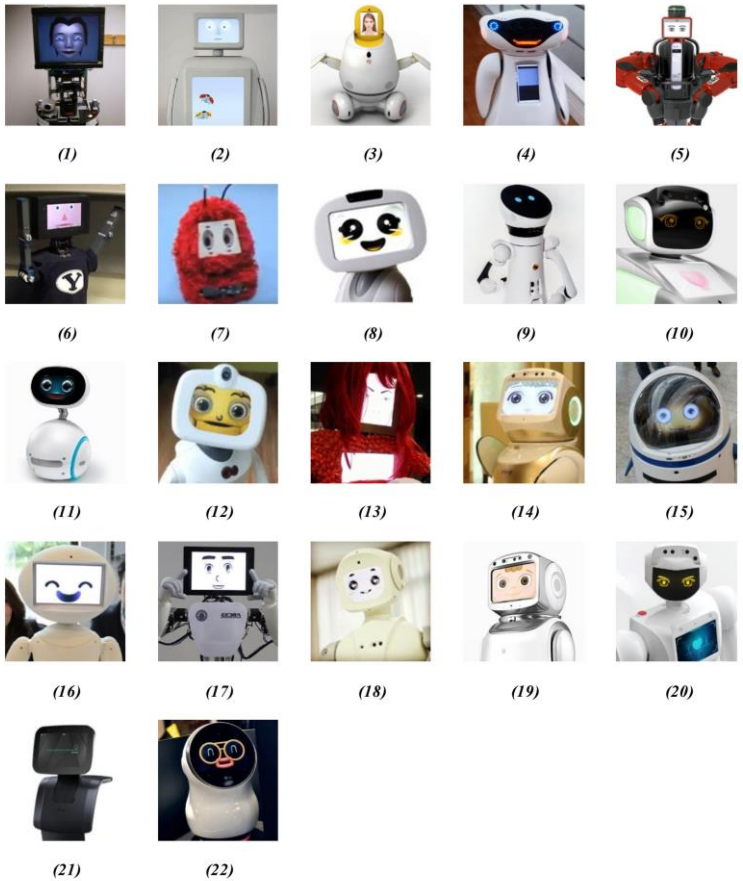


Physical appearance of robots

A survey on social Robots' DoF

صفحه نمایش تخت به عنوان صورت

ردیف	نام ربات	سال تولید	تعداد درجات آزادی در سر و گردن
(1)	Grace	2002	0
(2)	Iromec	2010	1
(3)	EngKey	2010	1
(4)	Monarch	2011	1
(5)	Baxter	2012	0
(6)	Troy	2012	2
(7)	Romibo	2015	0
(8)	Buddy	2015	2
(9)	Care-O-ot 4	2015	4
(10)	Sanbot Elf	2016	2
(11)	ASUS Zenbo	2016	2
(12)	Robelf	2016	2
(13)	Fortune Teller Robot	2016	2
(14)	Zunpeng Xiaobao	2016	2
(15)	Little Chubby	2016	0
(16)	LuxAI	2016	2
(17)	Rasa	2016	3
(18)	Dr. Arash	2017	2
(19)	Sanbot Nano	2017	2
(20)	Sanbot Max	2017	2
(21)	Temi Robot	2017	1
(22)	LG CLOi	2018	0

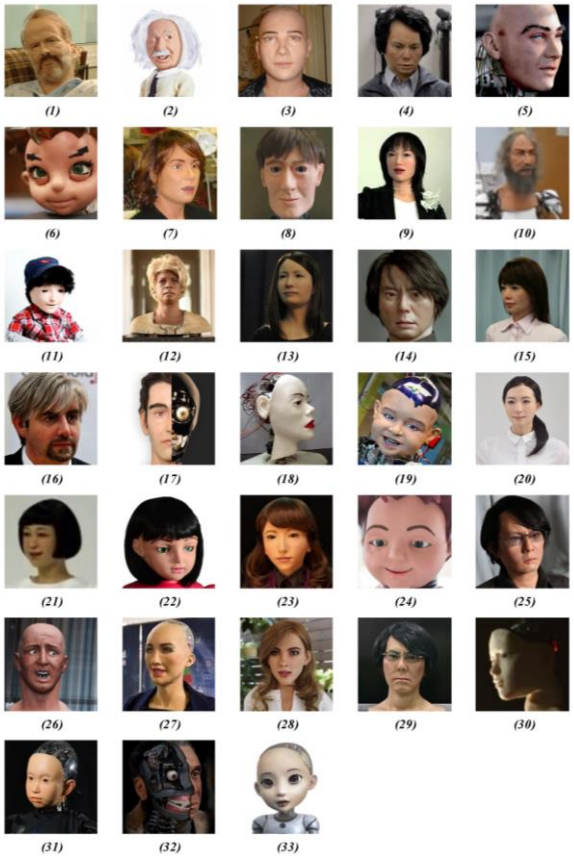


Physical appearance of robots

A survey on social Robots' DoF

پوست صورت با قابلیت ارتجاعی

ردیف	نام ربات	سال تولید	تعداد درجات آزادی در سر و گردن
(1)	Philip K Dick	2005	36
(2)	Albert HUBO	2005	28
(3)	Jules	2006	-
(4)	Geminoid HI-1	2006	-
(5)	Joey Chaos	2007	-
(6)	Zeno	2007	32
(7)	Alice (Eva)	2008	-
(8)	Roman	2008	-
(9)	Actroid	2009	-
(10)	Ibn Sina	2009	30
(11)	Kaspar	2009	8
(12)	BINA48	2010	32
(13)	Geminoid F	2010	11
(14)	Geminoid HI-2	2010	13
(15)	Repliee Q2	2011	-
(16)	Geminoid DK	2011	12
(17)	ToMoMi	2012	23
(18)	Animatronic Head (David Ng)	2012	16
(19)	Diego-San	2013	27
(20)	Kodomoroid	2014	-
(21)	Otonaroid	2014	-
(22)	Alice	2014	11
(23)	Erica	2015	-
(24)	Milo	2015	-
(25)	Geminoid HI-4	2015	12
(26)	Han	2015	-
(27)	Sophia	2016	-
(28)	Mark 1	2016	-
(29)	Geminoid HI-5	2017	-
(30)	Alter	2017	-
(31)	ibuki	2018	-
(32)	Mesmer	2018	-
(33)	Little Sophia	2019	-



Physical appearance of robots

A survey on social Robots' DoF

سر با اجزای ساده غیر متحرک

ردیف	نام ربات	سال تولید	تعداد درجات آزادی در سر و گردن
(1)	ASIMO	2000	3
(2)	Nao	2004	2
(3)	Maggie	2007	2
(4)	RH-1	2008	1
(5)	RIBA	2009	3
(6)	TAIZO	2009	2
(7)	REEM-C	2013	2
(8)	Pepper	2014	2


(1)


(2)


(3)


(4)


(5)


(6)


(7)

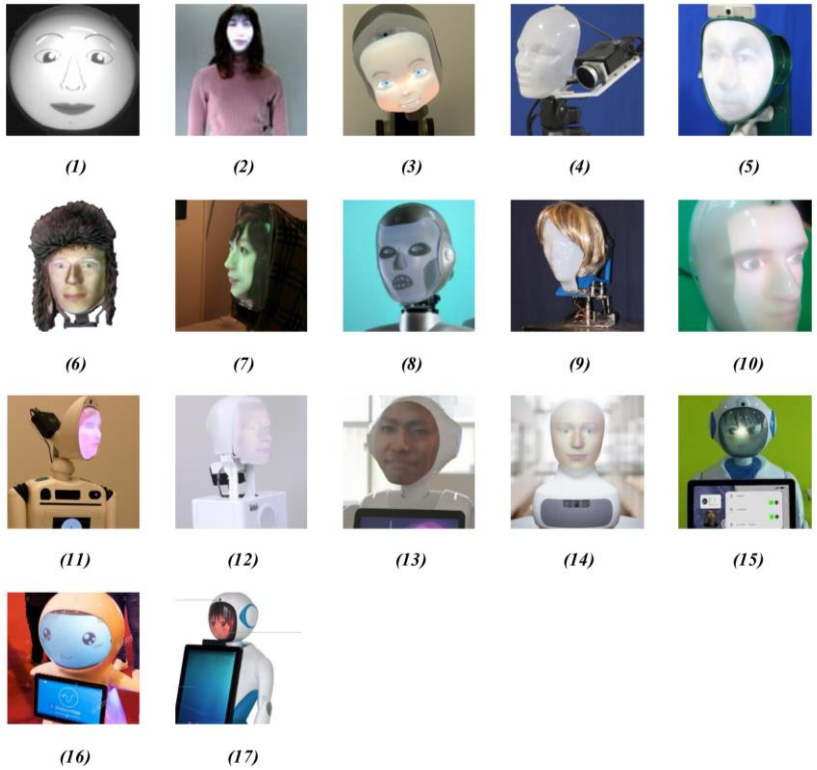
(8)

Physical appearance of robots

A survey on social Robots' DoF

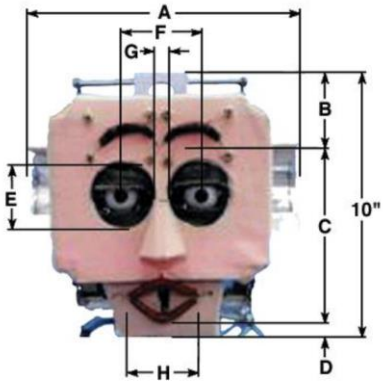
سر با پروژکتور

ردیف	نام ربات	سال تولید	تعداد درجات آزادی در سر و گردن
(1)	Dome	2005	3
(2)	Chatty	2007	-
(3)	LightHead	2009	-
(4)	Mask-bot	2011	-
(5)	Mask-bot 2i	2012	-
(6)	Furhat	2012	-
(7)	LiveMask	2013	-
(8)	Socibot	2014	-
(9)	ExpressionBot	2014	-
(10)	LightHead v4	2015	-
(11)	Ryan	2015	-
(12)	ID-Match	2016	-
(13)	Digital Shaman	2017	2
(14)	Furhat v2	2018	3
(15)	CSJBot	2018	-
(16)	Snow Robot	2018	0
(17)	Alice Plus	2018	2



Physical appearance of robots

A survey on social Robots' DoF جمع بندی طراحی سر ربات های اجتماعی

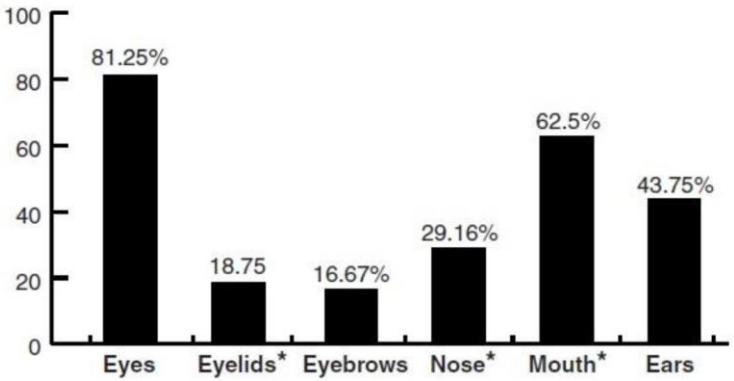


KEY TO PHYSICAL DIMENSIONS

A. Width of head
B. Top of head to browline
C. Features height
D. Bottom of lip to chin
E. Diameter of eye
F. Pupil distance
G. Eye spacing
H. Mouth width

	مکانیکی	نمایشگر تخت	اندروید	با اجزاء ساده	با پروژکتور
هزینه‌ی راه‌اندازی	گران	ارزان	بسیار گران	نسبتاً ارزان	نسبتاً ارزان
هزینه‌ی نگهداری	گران	بسیار ارزان	گران	بسیار ارزان	بسیار ارزان
مقاوم بودن	زیاد	زیاد	کم	زیاد	زیاد
انعطاف‌پذیری	متوسط	زیاد	کم	کم	زیاد
واقعی بودن	کم	کم	زیاد	کم	کم
احتمال ورود به دره‌ی وهمی	کم	کم	زیاد	کم	متوسط
پذیرش توسط مخاطب	متوسط	نسبتاً خوب	نسبتاً خوب	نسبتاً خوب	خوب
مصرف انرژی	متوسط	کم	زیاد	کم	کم
سر و صدا	زیاد	ندارد	زیاد	ندارد	ندارد
وزن	نسبتاً زیاد	بسیار کم	نسبتاً زیاد	بسیار کم	بسیار کم
محدودیت نور محیط	ندارد	کم	ندارد	ندارد	نسبتاً زیاد

	حداقل	متوسط	حداکثر
قطر چشم	*0.25 in*	*1.75 in*	*4.75 in*
فاصله مردمک تا مردمک	*1.375 in*	*4 in*	*11.75 in*
عرض دهان	*0.875 in*	*3.75 in*	*9.25 in*
عرض سر	*5.25 in*	*9.63 in*	*20 in*
قسمت بالا	*8.75 %*	*35 %*	*62.5 %*
قسمت وسط	*28.75 %*	*60 %*	*100 %*
قسمت میانی	*6.25 %*	*11.88 %*	*27.5 %*

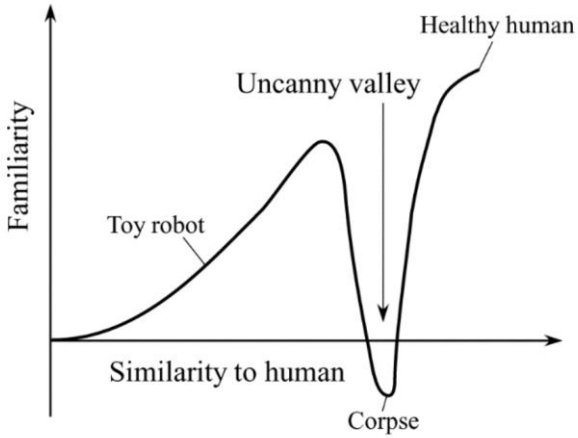


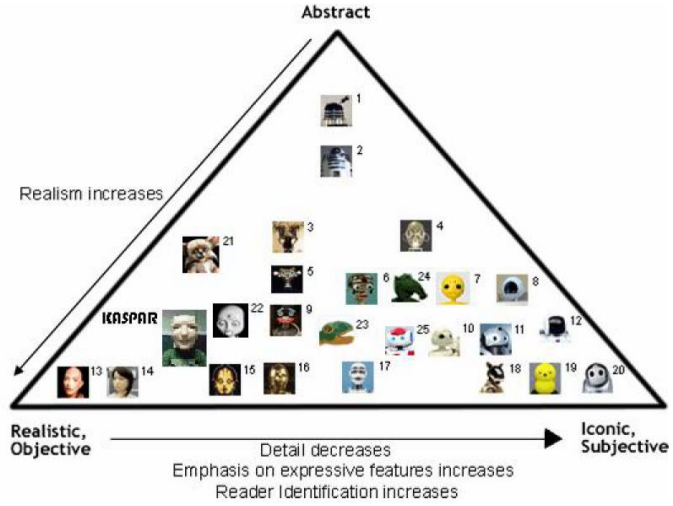
Physical appearance of robots

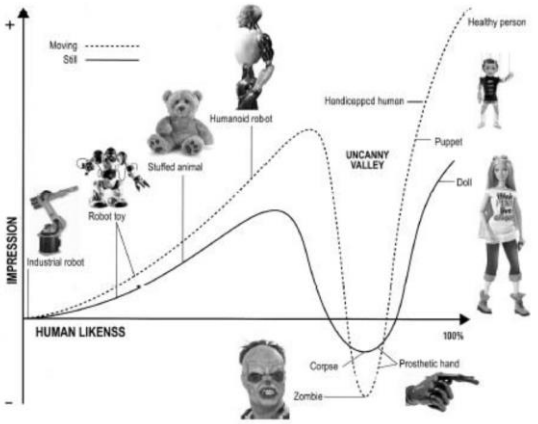
Design Consideration

- **Uncanny Valley**

When a humanoid robot's appearance is too close to a human, it causes fear and discomfort in the audience



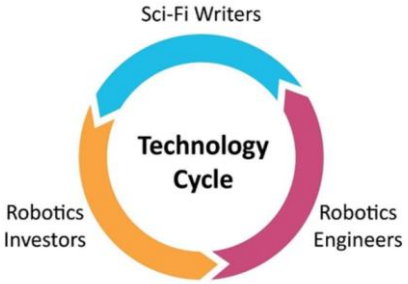




Physical appearance of robots

Fiction vs. Reality; a story

- During a visit to Carnegie Mellon University's Robotics Laboratory, Don Hall was inspired to create Baymax (The robot in Big Hero 6 (2014)). After making the film, Dr. Christopher G. Atkeson, a professor at that robotics lab, decided to make a real Baymax robot and defined a new field of projects called inflatable robotics. "It (Big Hero 6 (2014)) is a tremendous win for soft robotics," says Dr. Atkeson

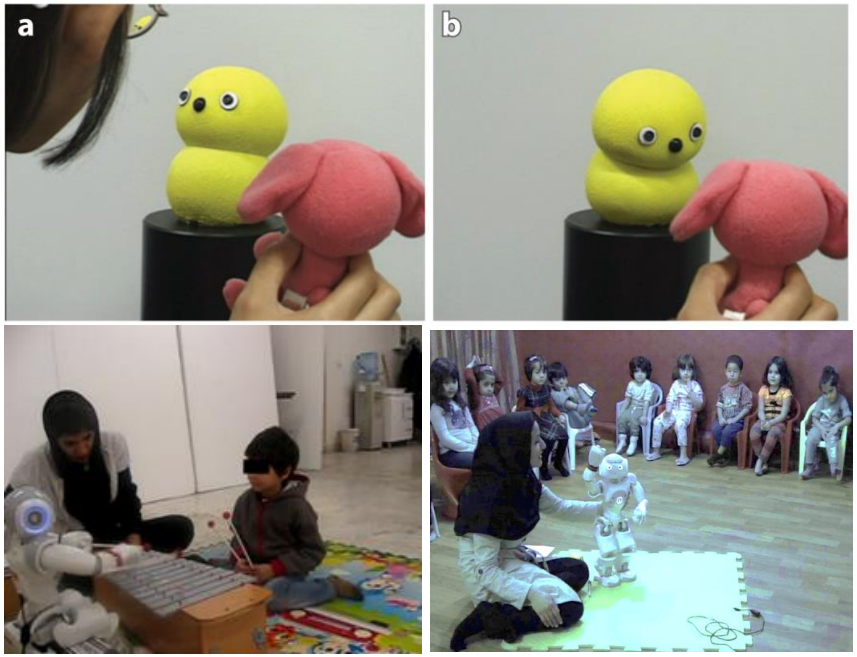


Ref: Saffari, E., Hosseini, S. R., Taheri, A., & Meghdari, A. (2021). "Does cinema form the future of robotics?": a survey on fictional robots in sci-fi movies. SN Applied Sciences, 3(6), 1-13.

Human-Robot Interaction

- A robot's behavior is critical to how it is perceived and how effective it might be.
- Human-robot interactions can be described both by the behaviors being elicited from the user and by the robot's role during the engagement.

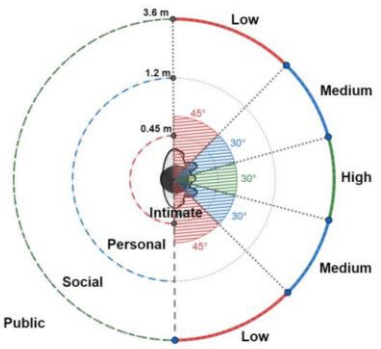
- HRI
  - Targeted Behavior
  - Roles of the Robot
  - Robot Autonomy

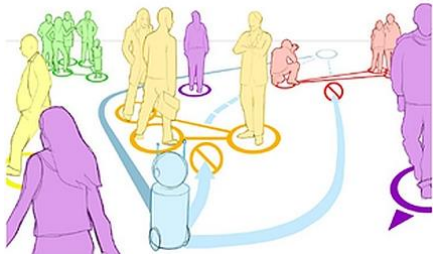


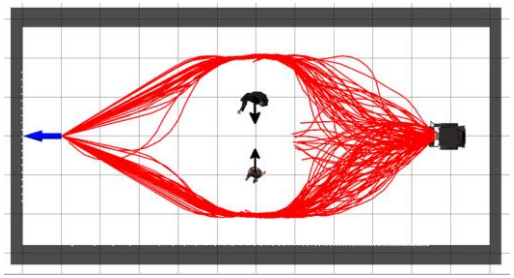
Human-Robot Interaction

Some Research Topics in Socio-Cognitive Robotics

- Non-Verbal and Verbal Communication
- Facial expressions
- Proxemics
- Gaze Control System
- Turn-taking interactions
- Imitation
- Socially aware navigation
- SLAM
- Action Recognition and Pose Estimation
- Speech Recognition
- …





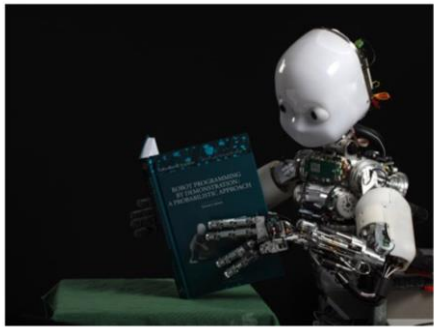


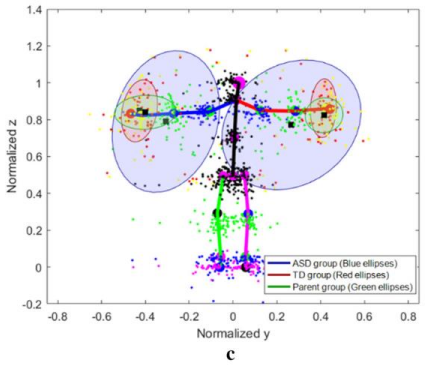
نشانه‌های غیر کلامی سیگنال‌هایی هستند که برای رساندن پیغامی معنادار به کار می‌روند و حدوداً دو سوم تعاملات انسانی را به خود اختصاص می‌دهند. انسان‌ها معمولاً از حالات چهره، اشارات بدن و دست، موقعیت سر و جهت نگاه برای جلب توجه، بیان احساس و انتقال پیام استفاده می‌کنند. نشانه‌های کلامی شامل آواها، لحن و صحبت می‌شود که به طور مستقیم توجه افراد را تحت تاثیر قرار می‌دهد.

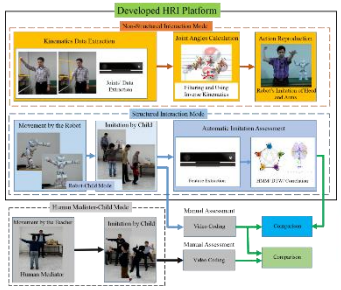
Human-Robot Interaction

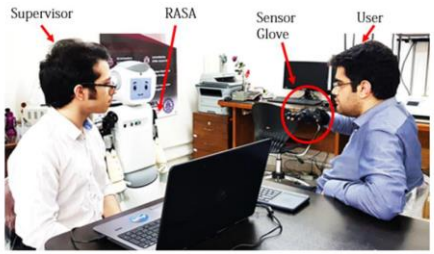
Requirements for socio-cognitive robots (combining machine learning algorithms, control theory, cognition theories, etc.)

- Safe, reliable, and transparent operation
- High-level instruction and context-aware task execution
- Knowledge Acquisition and Generalization
- Adaptive Planning
- Personalized Interaction
- Self-Assessment
- Learning from Demonstration
- Evaluating the Safety of Actions
- Communicating Intentions and Collaborative Action
- Development and Self-Optimization
- Knowledge Transfer





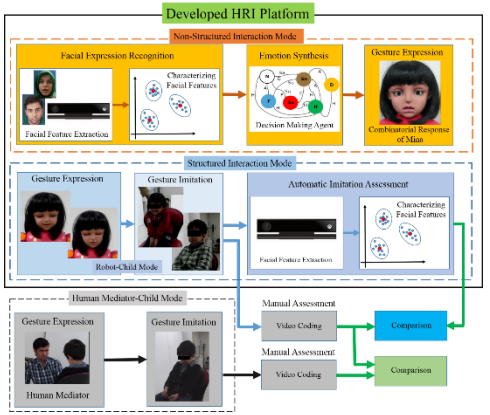


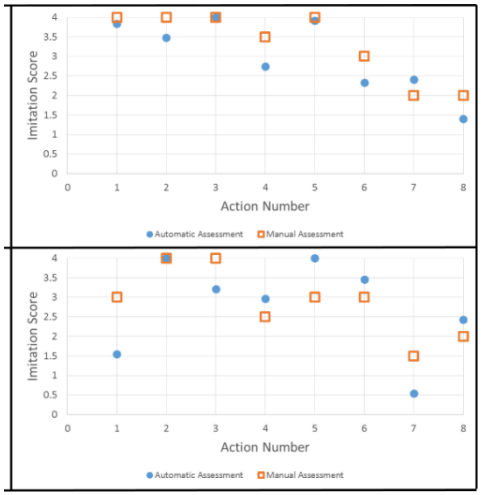


Ref: David Vernon, Cognitive Robotics Course

Human-Robot Interaction

Applications of Machine Learning in social human-robot interaction:
Human–Robot Facial Expression Reciprocal Interaction Platform

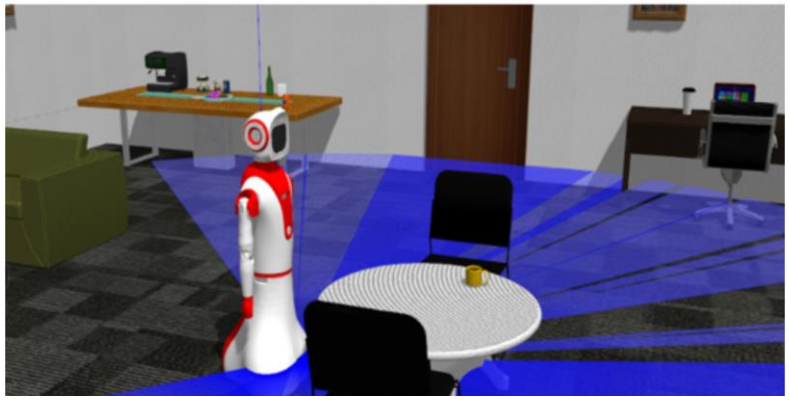


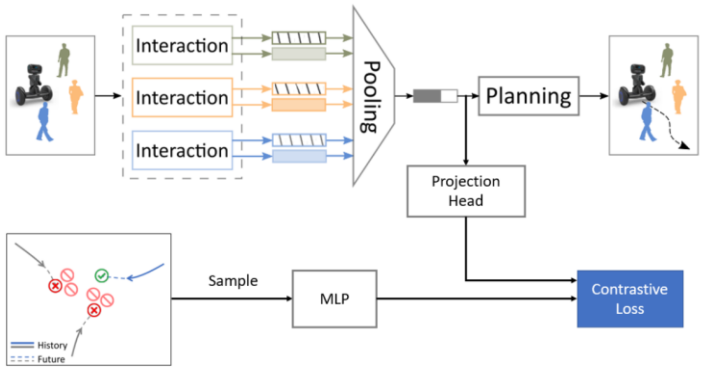


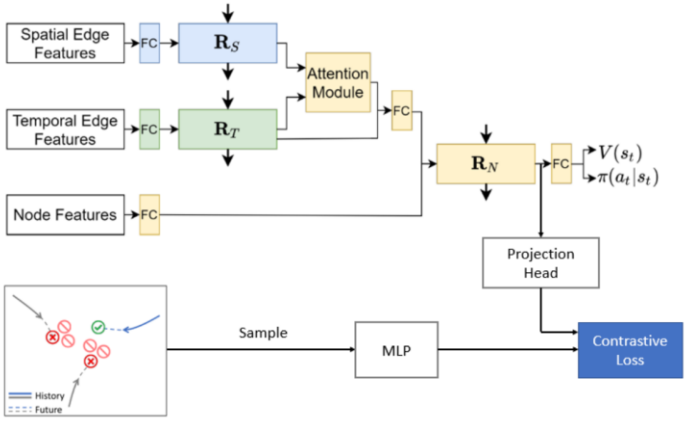
- **Acceptance** rate of ~78% for children with ASD
- Developing an **automated assessment system** for assessing facial imitation tasks

Human-Robot Interaction

Applications of Machine Learning in social human-robot interaction: Simultaneous Localization and Mapping (SLAM)







Human-Robot Interaction

Applications of Machine Learning in social human-robot interaction: Evolution of the GAN-based Talking Gesture Generation

Spontaneous Talking Gestures Using Generative Adversarial Networks

Igor Rodriguez, José María Martínez-Otzeta, Itziar Irigoien and Elena Lazkano

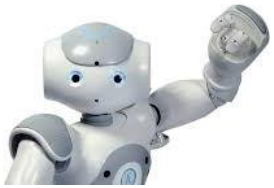
ROBOTIKA & SISTEMA AUTONOMOEN IKERKETA TALDEA

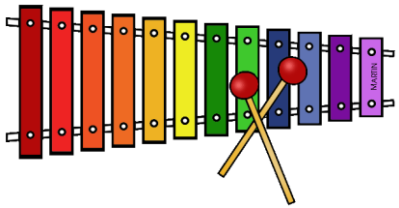
Universidad del País Vasco — Euskal Herriko Unibertsitatea

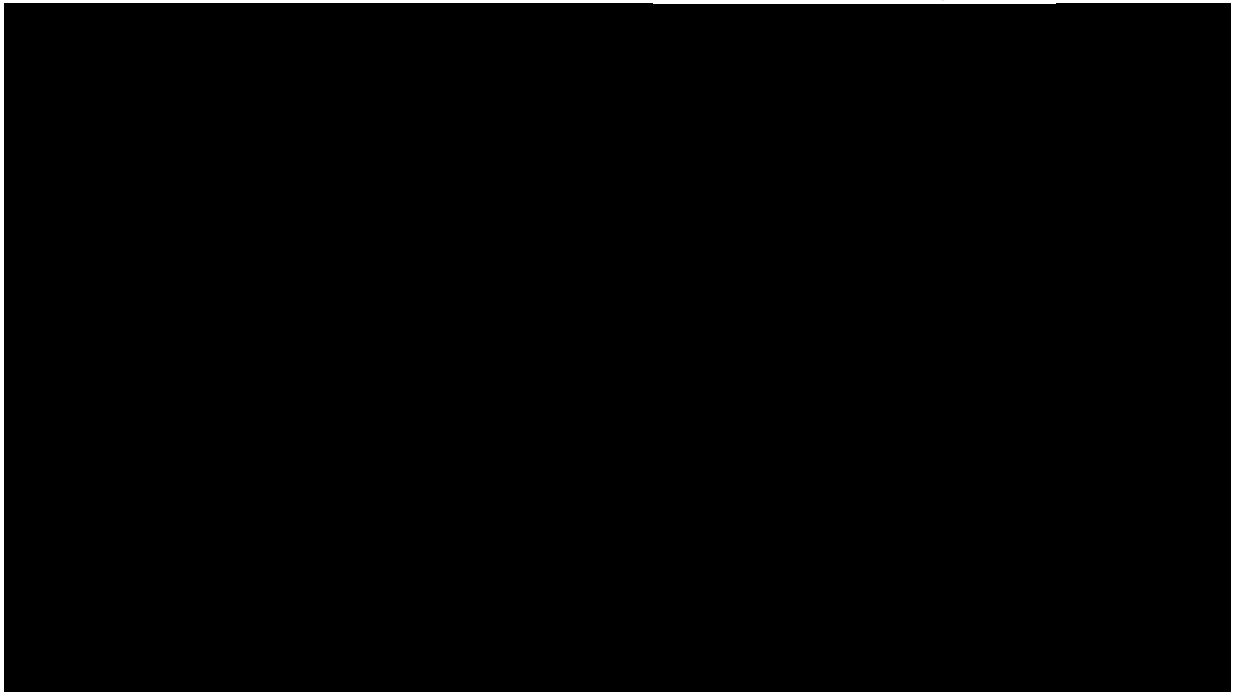
Ref: Rodriguez, I., Martínez-Otzeta, J. M., Irigoien, I., & Lazkano, E. (2019). Spontaneous talking gestures using generative adversarial networks. Robotics and Autonomous Systems, 114, 57-65.

Human-Robot Interaction

Cognitive Rehabilitation: Teaching Music to Children with Autism





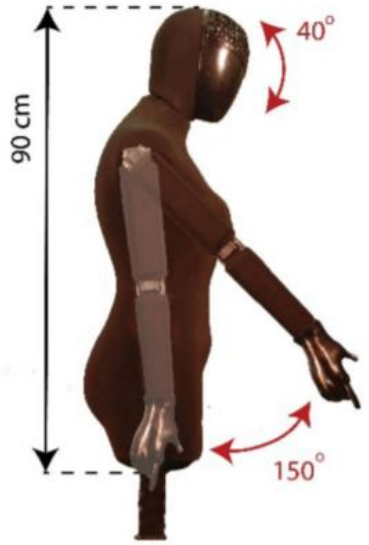


Human-Robot Interaction

RASA-I Robot: Teaching Iranian Sign Language to Children with Hearing Problems

Human-Robot Interaction

RoMa Robot; an Interactive Social Robot for fashion industry



Design a robot and HRI

Taban-II Robot

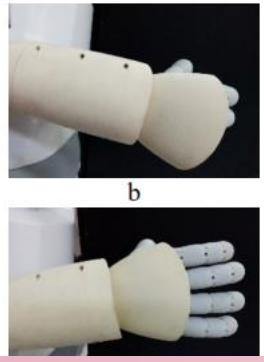
Design a robot and HRI

Apo Robot

شناسایی یک نیاز در جامعه (عمدتا برای کودکان)

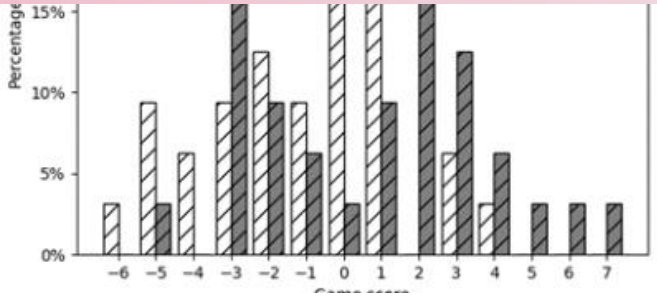
Evaluation of interventions

Social Robots and Entertainment



Evaluation of interventions will be studied in the last chapter

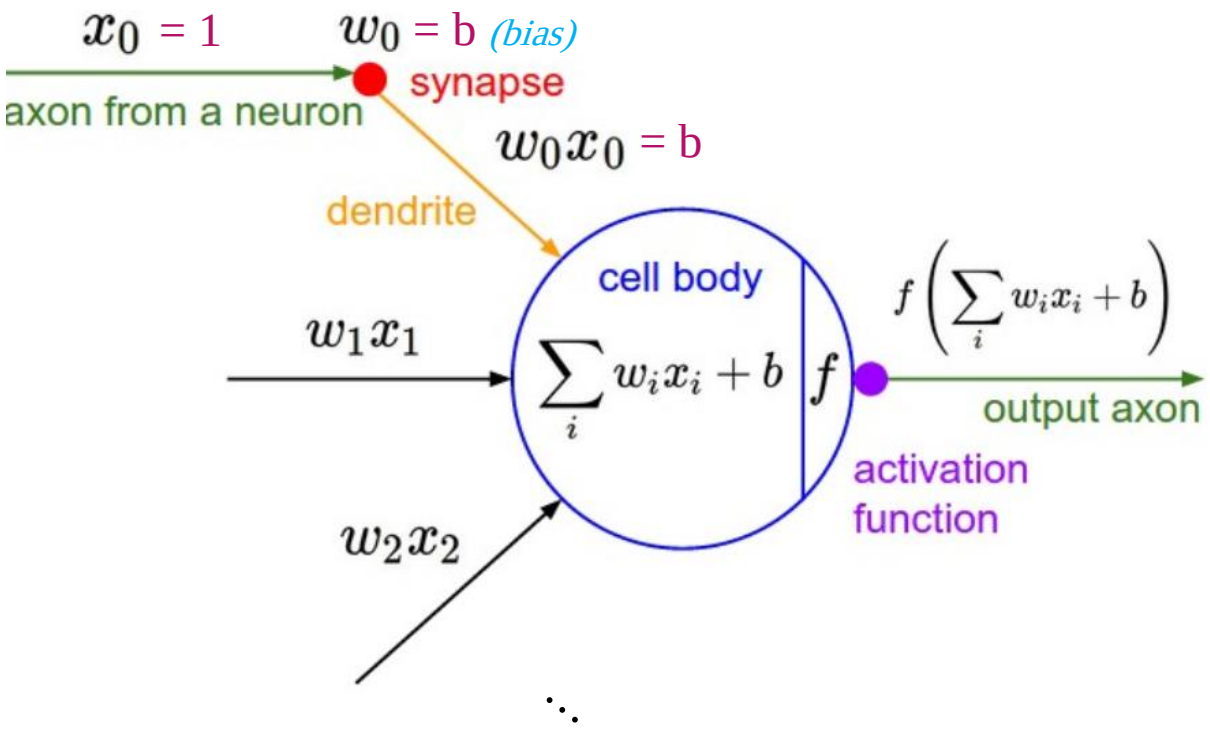
Overall Viewpoints about the HRI game		
No.	*Questions*	*Answer: 1 2 3 4 5*
1	I find the robotic-assisted game pleasant.	
2	I find the robot enjoyable.	
3	How understandable was the actions of the RASA robot during the RPS game?	
4	I believe that the time duration of the game was unusual. *(inverse question)*	
5	In each of the game's round, I tried to beat the robot.	
Comparison Questions		
No.	*Questions*	*1st Mode: 1 2 3 4 5* / *2nd Mode: 1 2 3 4 5*
6	How intelligent was the robot's decisions in playing the Rock- Paper- Scissors game?	
7	Which algorithm do you prefer to be used by the robot to continue playing the game?	*First or Second?*



Question # *(Scores are out of 5)*	Mean *(SD)*		T-Value	P-Value
	a: Markov Chain-based strategy	b: Random strategy		
Q6	3.344 *(0.787)*	2.781 *(0.906)*	2.65	**0.010**

Basics of Perceptron *in Neural Networks*

Next Session …



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Thanks for your attention