Porazdeljene inteligentne programske tehnologije

Spoznavni sistemi

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Spoznavnost

- Spoznavni sistem = kognitivni sistem = cognitive system
- SSKJ:
  - **spoznáven** -vna -o prid. (á ā) *nanašajoč se na spoznavanje, spoznanje:* spoznavni nagibi; razčleniti spoznavni proces / človekove spoznavne sposobnosti … filoz. spoznavna teorija *filozofska disciplina, ki obravnava izvor, strukturo, metodo spoznavanja in veljavnost spoznanja*
  - **spoznávati** -am nedov. (á̋) **1.** *na osnovi zaznav, podatkov in umske dejavnosti prihajati do* a) *poznavanja česa:* človek vse bolj spoznava naravo; spoznavati, kako deluje celica / v šoli spoznavati prve črke; spoznavati računalništvo b) *védenja:* spoznavati lastne zmote; vse bolj je spoznaval, da tako ne more več živeti / spoznavati otrokovo nadarjenost

Cognition

- Britannica Concise Encyclopedia:

  Act or process of **knowing**. Cognition includes every mental process that may be described as an experience of knowing (including **perceiving, recognizing, conceiving, and reasoning**), as distinguished from an experience of feeling or of willing.

- Sci-Tech Encyclopedia:

  The internal structures and processes that are involved in the acquisition and use of **knowledge**, including **sensation**, **perception**, **attention**, **learning**, **memory**, **language**, **thinking**, and **reasoning**. Cognitive scientists propose and test theories about the functional components of cognition based on observations of an organism's external behavior in specific situations.

Cognition

- Wikipedia:

  The term **cognition** (Latin: cognoscere, "to know") is used in several loosely related ways to refer to a faculty for the **human-like processing of information**, applying **knowledge** and changing preferences. Cognition or cognitive processes can be natural and artificial, conscious and not conscious; therefore, they are analyzed from different perspectives and in different contexts, in *anesthesia, neurology, psychology, philosophy, systemics and computer science.* The concept of cognition is closely related to such abstract concepts as **mind**, **reasoning**, **perception**, **intelligence**, **learning**, and many others that describe numerous capabilities of the human mind and expected properties of artificial or synthetic intelligence. Cognition is an **abstract property** of advanced living organisms; therefore, it is studied as a direct property of a brain or of an abstract mind on sub-symbolic and symbolic levels.

Cognition

- Wikipedia:

  In psychology and in artificial intelligence, it is used to refer to the **mental functions**, **mental processes** and **states of intelligent entities** (humans, human organizations, highly autonomous robots), with a particular focus toward the study of such mental processes as **comprehension, inferencing, decision-making, planning and learning** (see also cognitive science and cognitivism). Recently, advanced cognitive researchers have been especially focused on the capacities of **abstraction, generalization, concretization/specialization** and **meta-reasoning** which descriptions involve such concepts as **beliefs**, **knowledge, desires, preferences** and **intentions** of intelligent individuals/objects/agents/systems.

Cognitive science

- Wikipedia:

  Cognitive science is most simply defined as the scientific study either of **mind** or of **intelligence**. It is an interdisciplinary study drawing from relevant fields including **psychology**, **philosophy**, **neuroscience**, **linguistics**, **anthropology**, **computer science**, and **biology**.

Spoznavna robotika

- Wikipedia:

  Cognitive robotics is concerned with endowing **robots** with mammalian and **human-like cognitive capabilities** to enable the achievement of complex goals in complex environments. Robotic cognitive capabilities include **perception processing, attention allocation, anticipation, planning, reasoning about other agents**, and perhaps reasoning about their **own mental states**. Robotic cognition embodies the **behaviour of intelligent agents** in the **physical world**.

- A cognitive robot should exhibit:
  - knowledge
  - beliefs
  - preferences
  - goals
  - informational attitudes
  - motivational attitudes (observing, communicating, revising beliefs, planning)

Enota EU cognition

- **Research Rationale:**
  By promoting research into systems that have cognitive functions normally associated with people or animals and which exhibit a high degree of **robustness** in coping with **unpredictable situations**, we seek to overcome limitations of today's computers, robots, and other man-made creations to handle simple **everyday situations** with common sense and to work **without pre-programming** in **natural surroundings**, while maintaining and possibly improving the quality of their services.
- **Unit Mission:**
  We support research on the construction of **artificial cognitive systems** than can **interpret information** (images, text, speech, video footage) and other forms of sensor data, and **act purposefully** and **autonomously** towards achieving **goals**.
  These systems should **learn** and **develop** through individual or social **interaction** with their **environment**. The work should provide an enabling technology that applies across domains such as natural *language understanding, image recognition, automated reasoning and decision support, robotics and automation, sensing and process control, and complex real-world systems*. The work should furthermore borrow insights from the *bio-sciences*, and yield innovative insights about perception, understanding, interaction, learning and knowledge representation.

Definicije raziskovalcev

- Cognition is the ability to relate perception and action in a meaningful way determined by experience, learning and memory. *Mike Denham*
- A cognitive system possesses the ability of self-reflection (or at least self-awareness). *Horst Bischof*
- Cognition is gaining knowledge through the senses. *Majid Mermehdi*
- Cognition is the ability to ground perceptions in concepts together with the ability to manipulate concepts in order to proceed toward goals. *Christian Bauckhage*
- An artificial cognitive system is a system that is able to perceive its surrounding environment with multiple sensors, merge this information, reason about it, learn from it and interact with the outside world. *Barbara Caputo*
- Cognition is self-aware processing of information. *Cecilio Angulo*
- Cognitive Systems are ones that are able to extract and (most importantly) represent useful aspects of largely redundant, possibly irrelevant sensory information in a form that is most conducive to achieving a particular high level goal. *Sethu Vijayakumar*
- A cognitive system is a system that can change its behaviour based on reasoning, using observed evidence and domain knowledge. *Bob Fisher*
- Cognition is when I know what I am doing, when I can judge how good or bad it is, and explain why I am doing it. *Markus Vincze*
- Cognition is the ability to plan, reason, adapt and act according to high level motivations or goals and using a range of senses, typically including vision, and may be communicate. *Patrick Courtney*
- A cognitive system is an autonomous anti-entropy engine. *David Vernon*

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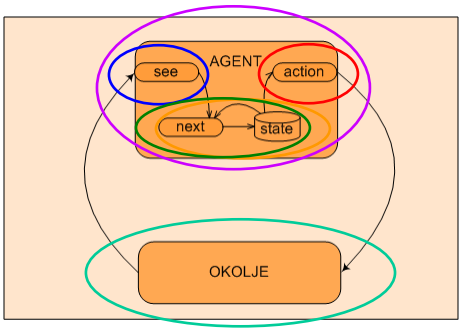
Glavni poudarki

- Zaznavanje (perception)
- Akcija (action)
- Sklepanje, načrtovanje (reasoning, planning)
- Cilji (goals)
- Avtonomija, samozavedanje (autonomy, self-awareness)
- Okolje (environment)



Zahteve za spoznavne sisteme

- Kakšne zahteve morajo izpolnjevati spoznavni sistemi:
  - Arhitektura
  - Zaznavanje
  - Predstavitve
  - Učenje
  - Razpoznavanje
  - Akcija
  - Načrtovanje
  - Sklepanje
  - Komunikacija

Arhitektura

- Arhitektura:
  - Odzivna
  - Proaktivna
  - Fleksibilna
  - Učinkovita
  - Skalabilna/razširljiva
  - Mora povezovati različne komponente (zelo nehomogen sistem)
  - Samozavedanje in samorazumevanje
  - Se jo da praktično realizirati/vzdrževati/razvijati,…

Zaznavanje

- Zaznavanje:
  - Vizualna informacija (slika, video; barvna, ČB, IR,…)
  - Zvok (govor, glasba, šum, …)
  - Haptična informacija - dotik (haptični senzorji, senzorji trka, itn)
  - Globinska/prostorska informacija (globinske slike, 3D modeli, 3D zemljevidi, …)
  - Veliko različnih modalnosti - spoznavni sistem je zelo večmodalen sistem
- Pozornost
  - Selektivno zaznavanje
  - Obvladovanje kompleksnosti potencialnih vhodnih signalov

Predstavitve

- Predstavitve (reprezentacije) zaznav, sveta, notranjega stanja, načrtov, komunikacije, motivov, itn.
  - **Modalne** predstavitve - predstavitve zaznav (vseh modalnosti), vezane na določeno modalnost
  - **Amodalne** predstavitve – abstrakcija modalnih predstavitev
  - Spozavni sisem mora znati povezovati različne predstavitve ter jih abstrahirati na višji abstrakcijski (semantični) nivo - **binder**
  - Dodatne zahteve:
    - Inkrementalno osveževanje predstavitev
    - Različni načini učenja
    - Skalabilnost
    - Primernost za sklepanje in načrtovanje
    - Omogočajo introspekcijo, detekcijo neznanja
  - Prirojeno:naučeno

Učenje

- Učenje
  - Različni načini učenja
    - Usmerjano
    - Deloma usmerjano
    - Popolnoma samostojno
  - Kontinuirano učenje
    - Vseživljensko, neprestano učenje
    - Osveževanje predstavitev, tvorjenje novih
    - Detekcija neznanja
  - Učenje v vseh modalnostih
    - Združevanje rezultatov
    - "co-learning"
  - Pozabljanje, popravljanje napak ("unlearning")
  - Robustno, v vsakdanjih pogojih

Razpoznavanje

- Razpoznavanje
  - Objektov
  - Prostorov
  - Akcij
  - Funkcionalnih lastnosti predmetov
  - Govora
  - Namenov,…
- Kategorizacija (razpoznavanje kategorij)
- Večmodalno razpoznavanje

Akcija

- Cikel zaznava-akcija (perception-action)
  - Učinkovitost
  - Robustnost
  - Delovanje v nepredvidljivem okolju
  - Na voljo le delna informacija
  - Fleksibilnost
  - Utelešenost (embodiment)
  - Umeščenost v prostor (situatidness)
- Manipulacija s predmeti (robotska roka)
- Premikanje po prostoru (mobilni robot)

Načrtovanje

- Načrtovanje
  - V nepredvidljivem okolju
  - Brez popolne informacije
  - Z določenimi omejitvami robota
  - V spreminjajočem se okolju
- Kontinuirano načrtovanje
  - Prilagajanje na spremembe v okolju nastale med izvrševanjem načrta
  - Združevanje načrtovanja in izvajanja
- Aktivna detekcija napak
  - Robotska roka
  - Mobilni robot
- Sodelovanje med agenti
  - Sodelovanje/komunikacija s človekom
  - Sodelovanje/komunikacija z drugimi agenti

Sklepanje

- Sklepanje
  - V nepredvidljivem okolju
  - Brez popolne informacije
  - Z določenimi omejitvami robota
  - V spreminjajočem se okolju
  - Fleksibilnost in prilagodljivost
  - Upoštevanje različnih modalnosti
  - Amodalne predstavitve
  - Samozavedanje, introspekcija, detekcija neznanja
  - Komuniciranje znanja, neznanja

Komunikacija

- Komunikacija
  - S človekom
  - Z drugimi (drugačnimi) agenti
  - V določenem okolju in času

  - Prenos znanja
  - Razčiščevanje razumevanja
  - Koordinacija
  - Prevzemanje iniciative v dialogu

  - Prizemljevanje simbolov - Symbol grounding
  - Semantično opisovanje zaznav

  - Učenje jezika
    - sintaksa
    - širjenje ontologije
  - Učenje z uporabo jezika

Primer spoznavnega sistema

- Hišni robot Robi
- Ukažemo mu: "Prinesi mi pivo".

Primer

- Sosledje dogodkov:
  - Robot mora biti pozoren in poslušati za naš ukaz. *[pozornost, motivacija]*
  - Mora nas slišati in razumeti naš ukaz. *[zaznavanje, razpoznavanje govora, komunikacija]*
  - Postaviti si mora cilj in težiti k temu, da ga izpolni. *[cilj, proaktivnost]*
  - Mora vedeti kje se pivo nahaja, to se je moral prej naučiti. *[učenje]*
  - Mora narediti načrt kako nam bo prinesel pivo. *[načrtovanje]*
  - Mora poiskati najboljšo pot do hladilnika, na osnovi zemljevida, ki si ga je prej zgradil. *[navigacija, gradnja zemljevidov]*
  - Mora se premikati po načrtovani poti. *[akcija – premikanje]*
  - Po poti mora neprestano opazovati kam se giba. *[zaznavanje, akcija]*
  - Po poti se mora izogibati oviram. *[zaznavanje nevarnosti, ponovno načrtovanje, odzivnost]*

Primer

- Ko pride do hladilnika, se mora pravilno postaviti pred njega. *[utelešenost, umeščenost v prostor]*
- Mora znati odpreti hladilnik. *[razpoznavanje funkcionalnih lastnosti]*
- V hladilniku mora znati poiskati pivo (njegov izgled se je moral prej naučiti). *[zaznavanje, kategorizacija, učenje]*
- Načrtovati mora kako ga bo zagrabil. *[načrtovanje]*
- Na pravilen način bo zagrabil steklenico. *[akcija, vizualni nadzor, haptični nadzor]*
- Obrnil se bo in po obratni poti odšel nazaj do nas. *[načrtovanje, navigacija, akcija, zaznavanje nevarnosti, zaznavanje, razpoznavanje]*
- Robi: "Izvoli tvoje pivo". *[komunikacija]*

Primer spoznavnega sistema

- Kognitivni asistent
  - Razišče okolico in zgradi zemljevid, zna se gibati in izogibati oviram
  - Se nauči prepoznati in identificirati predmete
  - Razume namen in funkcije predmetov ter zna z njimi ravnati
  - Zna verbalno in neverbalno komunikacirati z ljudmi v okolici
  - Zazna nove situacije in ustrezno reagira ter načrtuje naslednje akcije
  - Deluje robustno, v vseh pogojih, v realnem domačem okolju

- Vgrajene osnovne funkcionalne sposobnosti, ki jih razvija in nadgrajuje z učenjem
- Vse komponente integrirane v enoten delujoč sistem

Primer spoznavnega sistema

- DARPA Urban Challenge
- Avtonomni avtomobili
- Vožnja po mestu
- Sposobnosti
  - Zaznavanje (slika, 3D, trk)
  - Načrtovanje
  - Sklepanje
  - Učenje
  - Navigacija
  - Izogibanje oviram
  - Akcija
  - Fleksibilnost
  - Robustnost
  - Učinkovitost
  - …

Spoznavni porazdeljeni sistemi

- Spoznavni sistemi so v splošnem porazdeljeni
  - Funkcionalno
  - Semantično
  - Fizično
- Posamezni deli
  - so zelo različni
  - uporabljajo različne podatke
  - delujejo asinhrono
- Spoznavni sistem kot nehomogen porazdeljen inteligenten agent
  - Sestavljen iz množice podsistemov, ki komunicirajo med seboj in težijo k istemu cilju
- Množica spoznavnih sistemov kot porazdeljen večagentni sistem
  - Sestavljen iz množice inteligentnih agentov, ki komunicirajo med seboj, sodelujejo in težijo k istemu cilju

Atributi spoznavnih sistemov

- Agenti:

Atribut	*Obseg vrednosti*
število	od ena naprej
uniformnost	homogeni - **nehomogeni**
cilji	nasprotni - **komplementarni**
arhitekture	**odzivne - preudarne**
sposobnosti (zaznavanje, spoznavanje,…)	enostavne – **napredne**

Atributi spoznavnih sistemov

- Interakcija:

Atribut	*Obseg vrednosti*
pogostost	majhna - **velika**
vztrajnost	kratkoročna - **dolgoročna**
nivo	posredovanje signalov – **posredovanje znanja**
vzorec (tok podatkov in nadzora)	**decentraliziran** – hierarhičen
spremenljivost	nespremenljiva- **spremenljiva**
namen	tekmovalen – **sodelovanje**

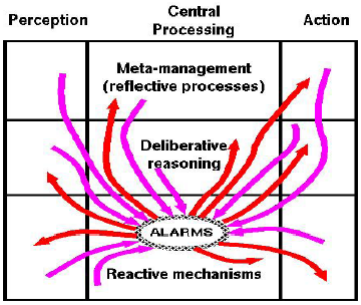
Atributi spoznavnih sistemov

- Okolje:

Atribut	*Obseg vrednosti*
predvidljivost	predvidljivo – **nepredvidljivo**
dostopnost in poznanost	neomejena – **omejena**
dinamičnost	nespremenljivo – **spremenljivo**
različnost	majhna – **bogata**
bogastvo z viri	omejeno - **obilno**

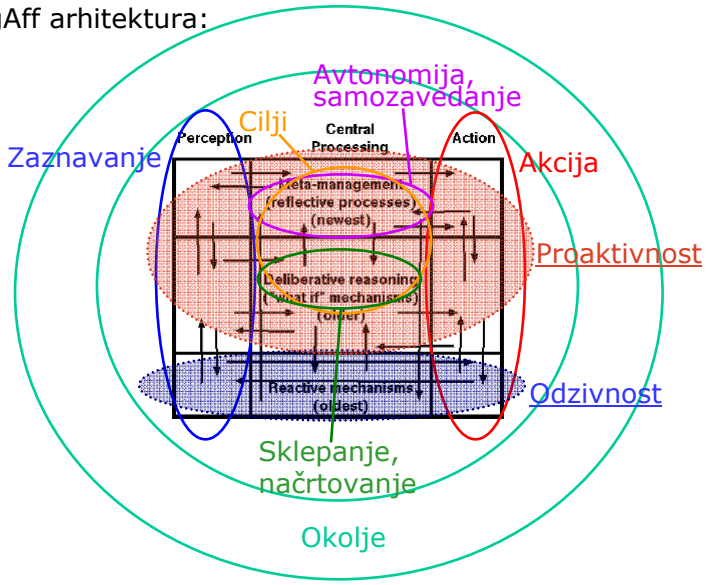
Arhitektura spoznavnih sistemov

- Veliko predlogov: SOAR, ACT, PRODIGY, ICARUS, 3T, APEX, CLARION, CIRCA, EPIC, itn.
- CogAff arhitektura:



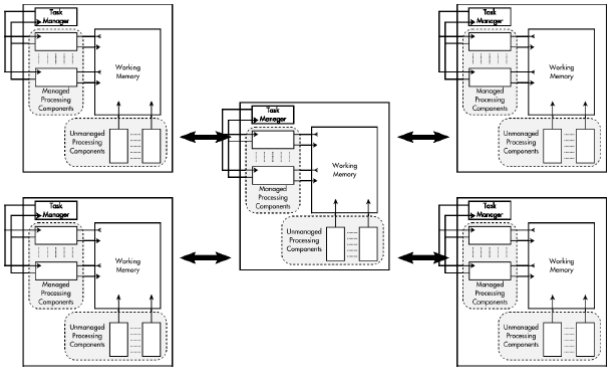
Arhitektura spoznavnega sistema

- CogAff arhitektura:



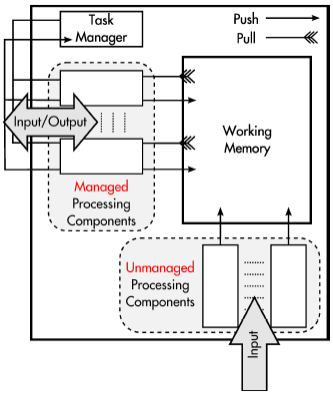
Arhitektura CAS

- CoSy architecture schema
- Zbirka rahlo povezanih podarhitektur
- Zelo različne komponente – zelo nehomogen sistem



Arhitektura CAS

- Ena podarhitektura:
  - Komponente
  - Osvežujejo strukture v delovnem pomnilniku (WM)
  - Komponente komunicirajo preko delovnega pomnilnika
  - Podarhitekture kmunicirajo z drugimi podarhitekturami preko delovnega pomnilnika
  - Upravitelj (task manager) upravlja s procesiranjem



PIPT CAS arhitektura

- CAS za komunikacijo med agenti