

AI Models and Methods in Safety-Critical Robotic Applications

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Decisional Autonomy

Decisional autonomy

Definition:

- The ability of the robot to act autonomously.

Levels:

- It ranges from the simple motion of an assembly stopped by a sensor reading, to the ability to be self sufficient in a complex environment.

Dependencies:

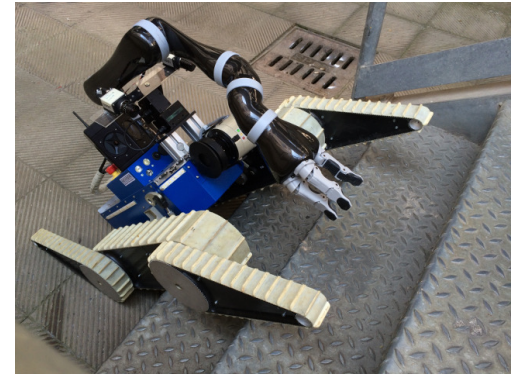
- Perception
- Cognition



Robotics 2020 Multi-Annual Roadmap. Horizon 2020 Call ICT-2017 (ICT-25, ICT-27 & ICT-28)

Levels (from 5 to 11)

- **Simple autonomy with environment model**
- **Task autonomy**
- **Constrained task autonomy**
- **Multiple task autonomy**
- **Dynamic autonomy**
- **Mission oriented autonomy**
- **Distributed autonomy**



Robotics 2020 Multi-Annual Roadmap. Horizon 2020 Call ICT-2017 (ICT-25, ICT-27 & ICT-28)

Dynamic autonomy

- The system is able to alter its decisions about actions (sub-tasks) within the time frame of dynamic events that occur in the environment so that the execution of the task remains optimal to some degree.
- Domain applications:
 - Civil
 - Commercial (toward mission oriented autonomy)
- Ability targets:
 - Decision validation mechanisms
 - User driven decisions
 - Certification of decisions
 - Decisions based on uncertain data
 - Decision layering

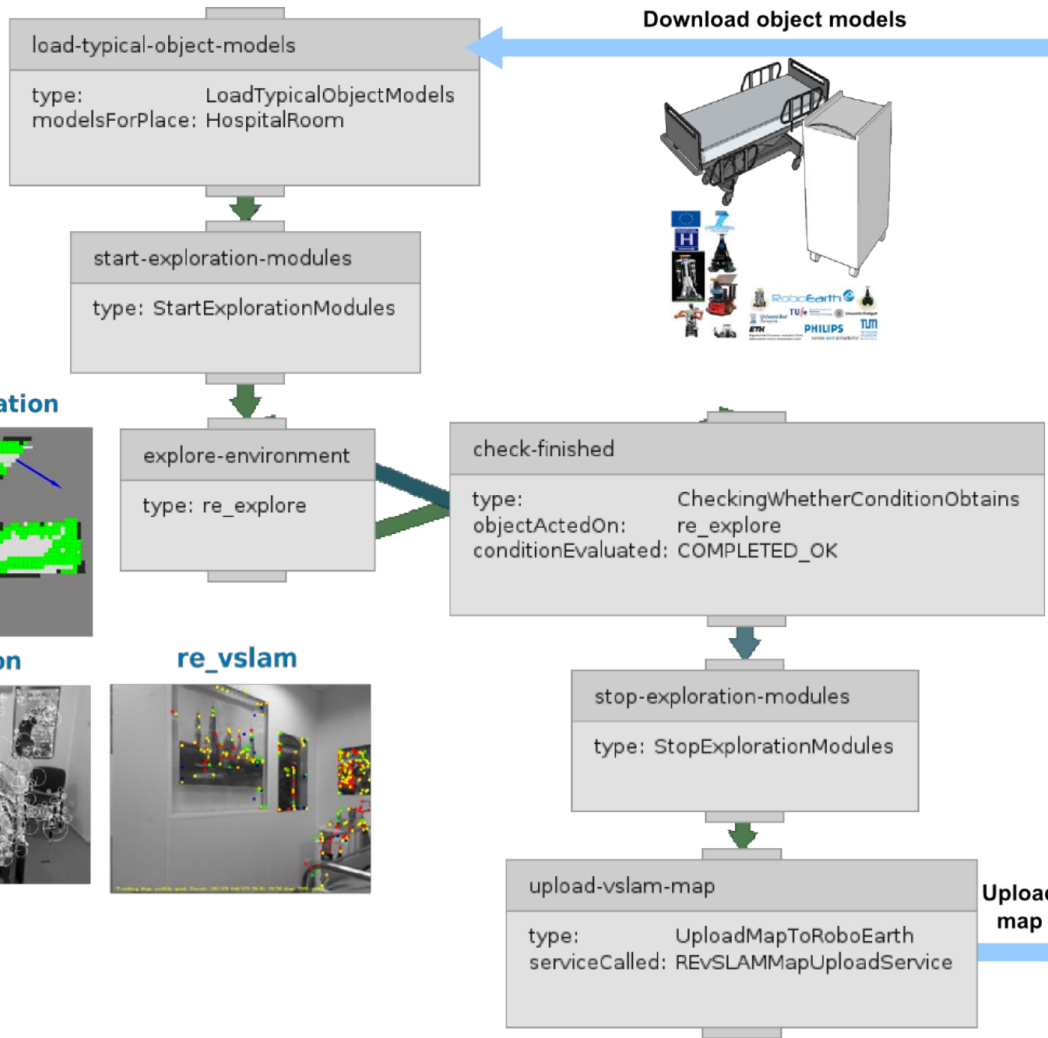


Robotics 2020 Multi-Annual Roadmap. Horizon 2020 Call ICT-2017 (ICT-25, ICT-27 & ICT-28)

Toward higher levels of autonomy




RoboEarth




Download object models







Action recipe




Object model




Environment map







Kinematic Robot model



Semantic Robot model

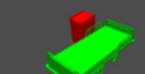


Robot Capabilities




SRDL
Semantic Robot Description Language

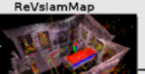
SemanticEnvironmentMap



OctoMap 3D






ReVslamMap



OWL

Web-based knowledge services



Knowledge Base | Robot Memory Replay | Editor | Log
RoboHow/Pizza-Rolling | knowrob/hydro-knowrob-daemon | Logout danielb

```

3 = 236.18338034795406
4 = 243.86963437515493
5 = 259.4965610503175
6 = 275.3834432227148
7 = 297.6354306730765
8 = 298.1049294893137
9 = 299.74520905650536
10 = 304.57140515683824
]

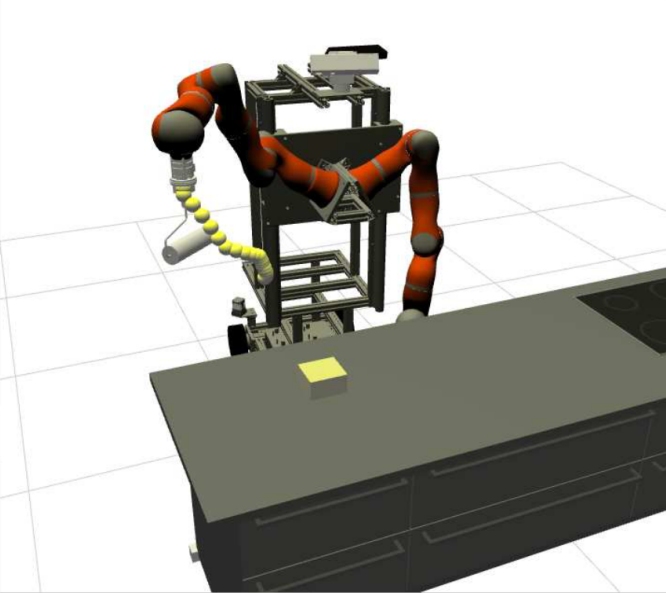
task_goal(Action, 'REPLACEABLE-FUNCTION
-ROLL-OBJECT'), get_reach_action(Action
,Reach), get_dynamics_image_perception
(Reach,Perc), once(designator_
publish_image(Perc)),show_action_trajecto
ry(Reach).
        
```

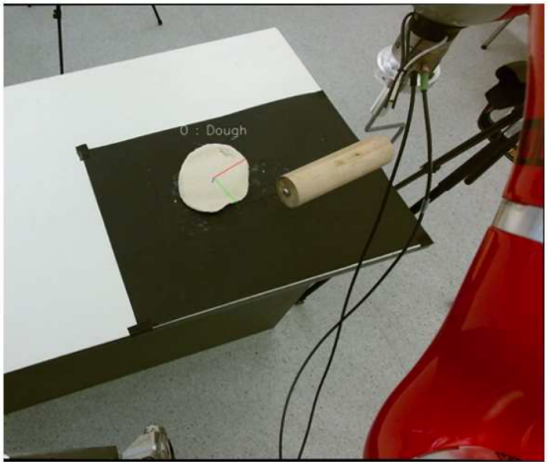
Query Next Solution

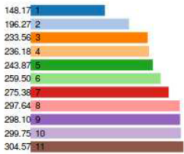
Initialize context
Load logged experiments
Load semantic map

----- Queries on the semantic map -----
What is the storage place for perishable items?
Which are electrical devices?

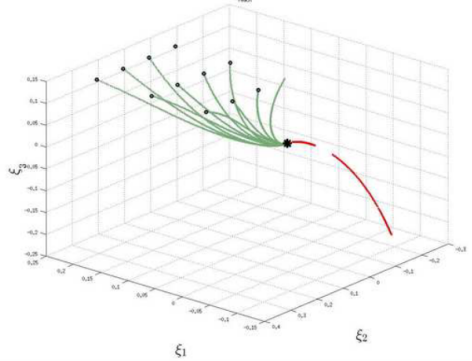
----- Queries on the logged belief state -----
Visualize boxy pre rolling
Visualize dough pre rolling
Visualize dough post rolling
Show the trajectory for reaching the dough
Show the trajectory for rolling the dough
Show the trajectory for going going back from r
How did the size of dough changed over time(c










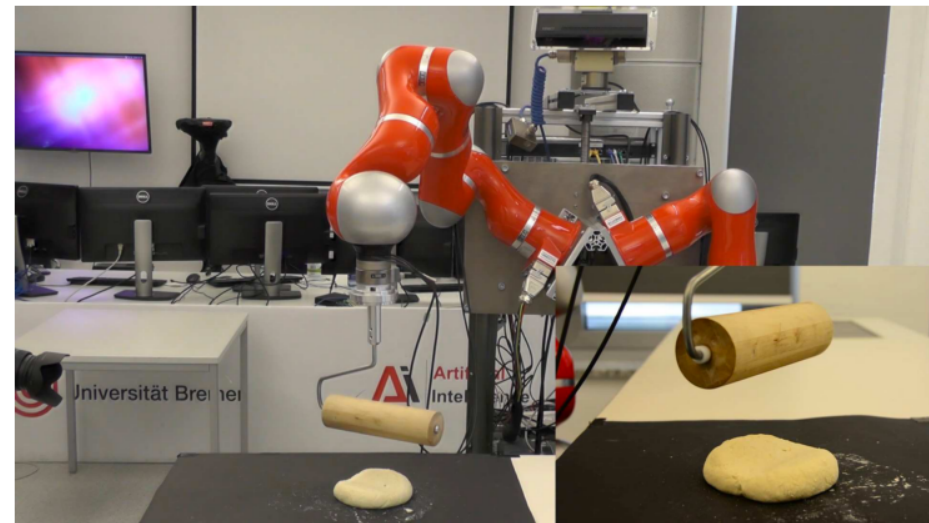
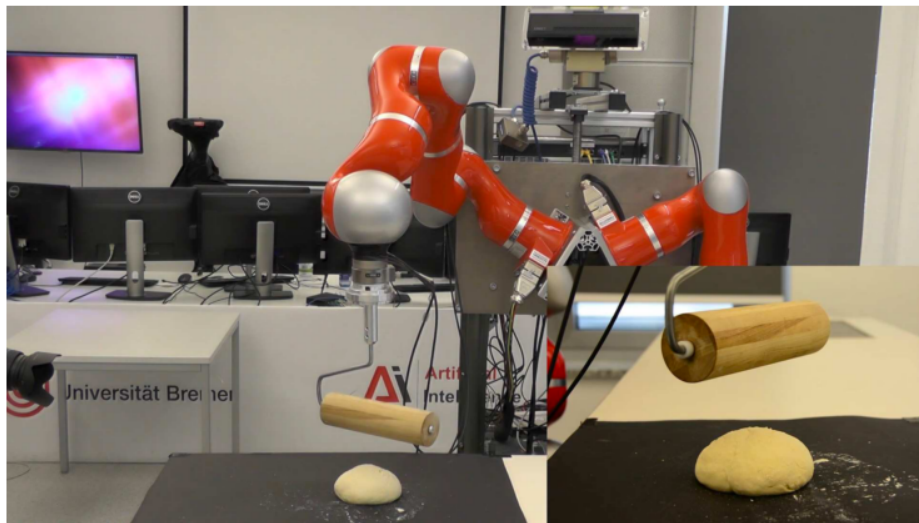


Step	Dough Size
3	236.18
4	243.87
5	259.50
6	275.38
7	297.64
8	298.10
9	299.75
10	304.57

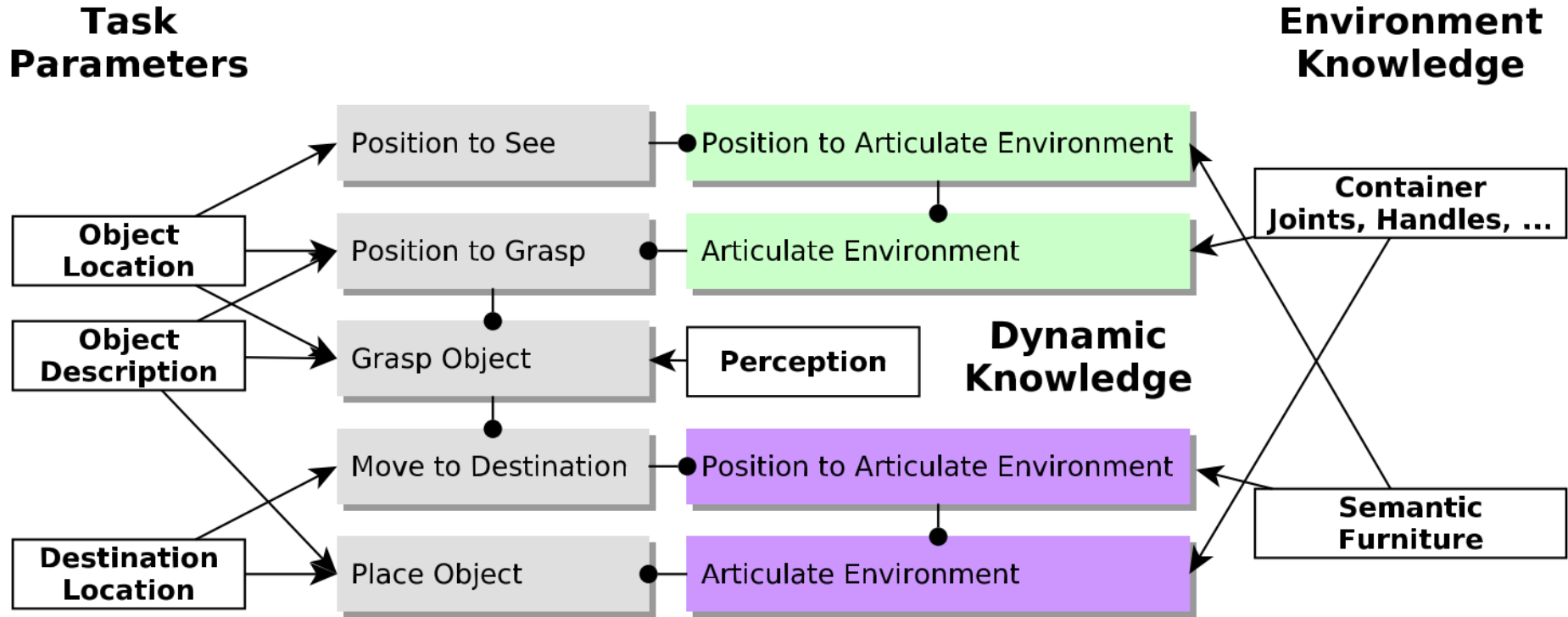


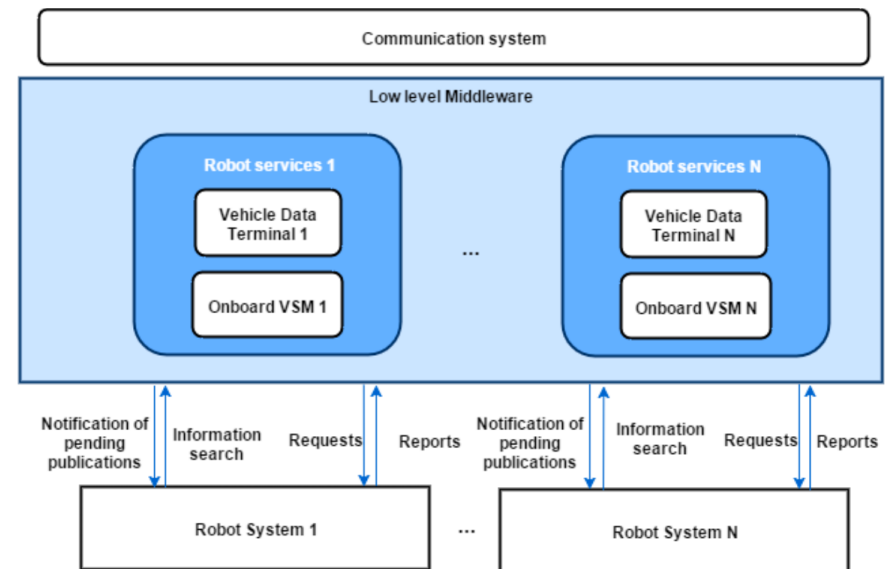
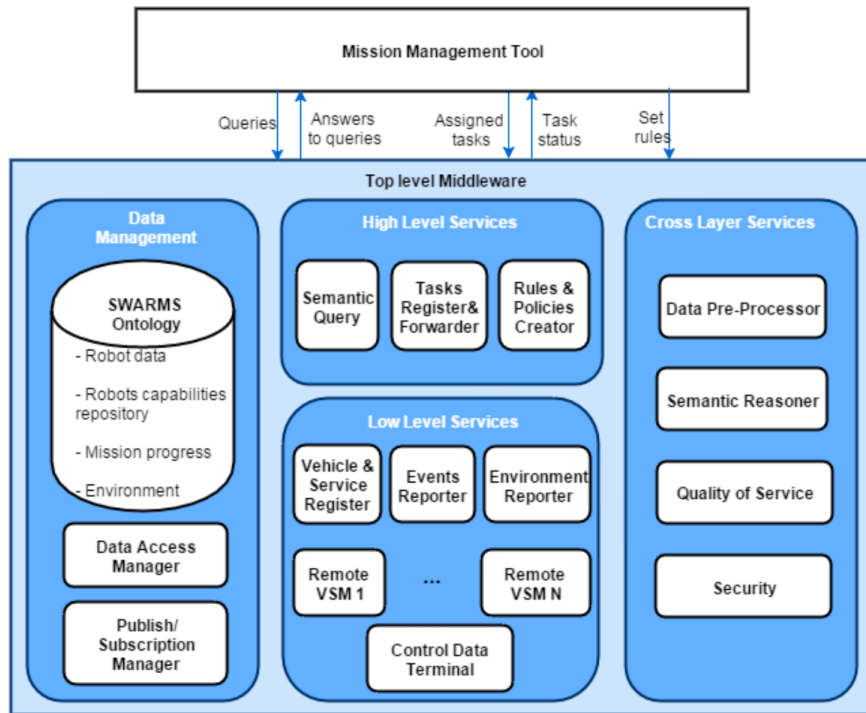
Web-based knowledge services



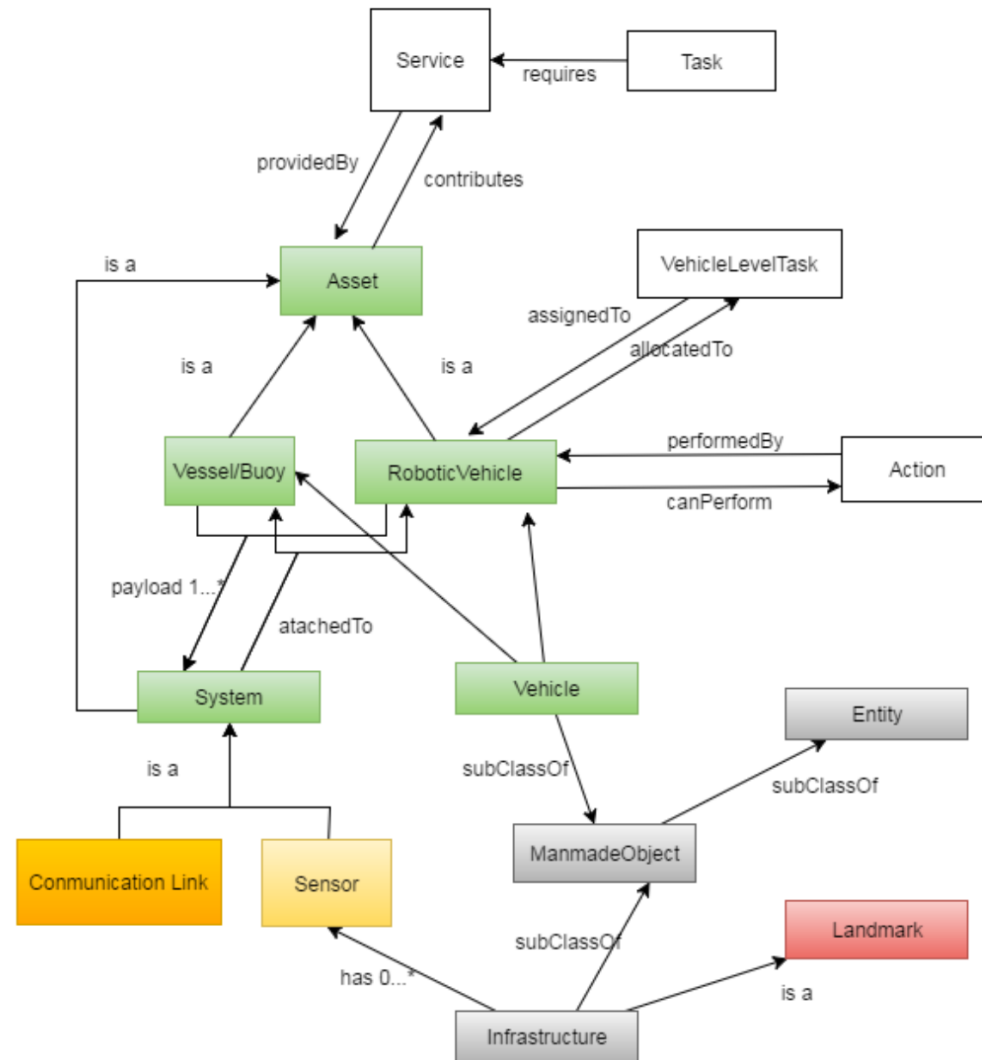
Web-based knowledge services



SWARM Ontology



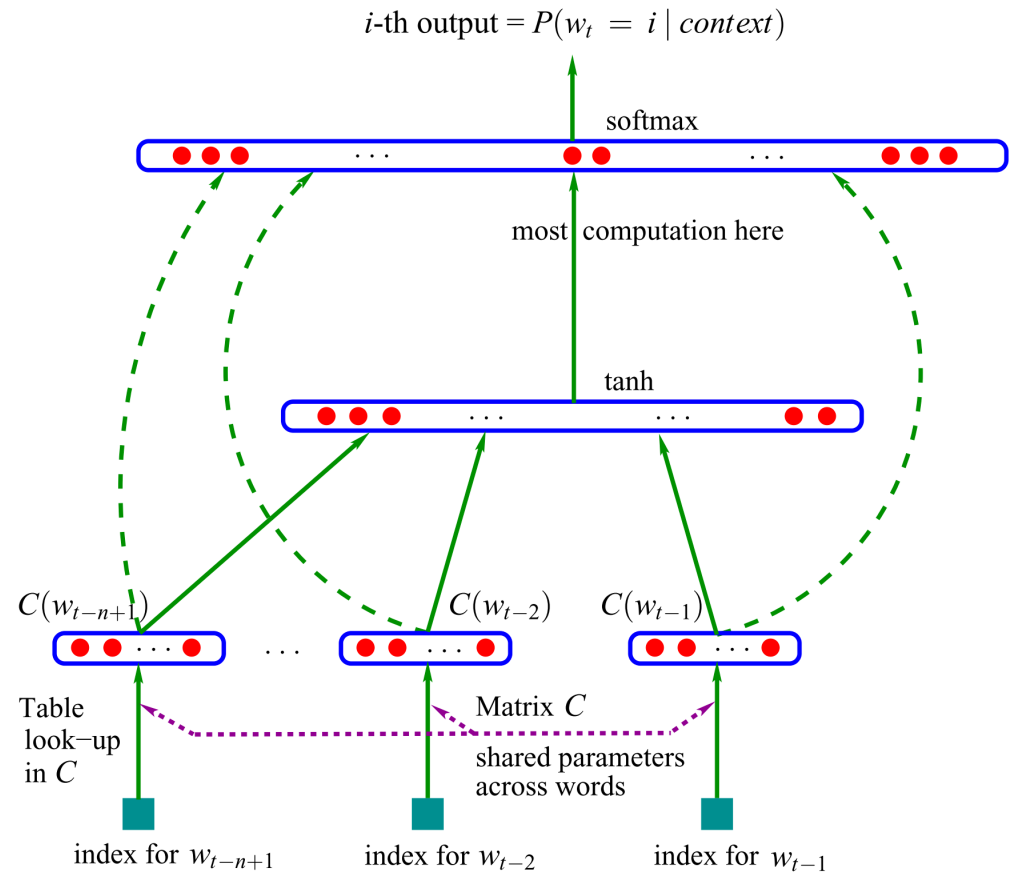
SWARM Ontology



Fighting the Curse of Dimensionality with Distributed Representations

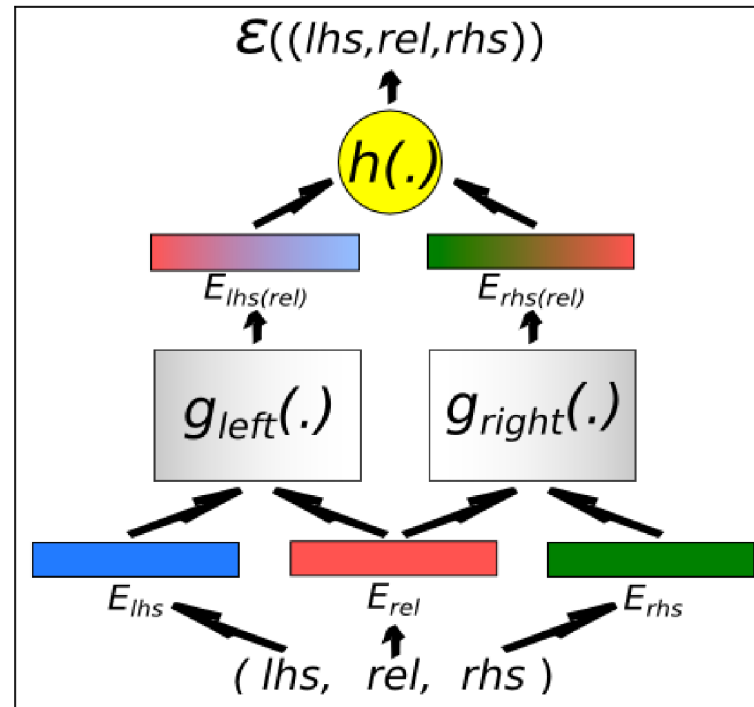
Neural Probabilistic Language Model

- simultaneously a distributed representation for each word along with the probability function for word sequences, expressed in terms of these representations.



Joint Learning of Words and Meaning Representations

0. Input (raw sentence): "A musical score accompanies a television program ."
1. Structure inference: `((_musical_JJ score_NN), _accompany_VB , _television_program_NN)`
2. Entity detection: `((_musical_JJ_1 score_NN_2), _accompany_VB_1, _television_program_NN_1)`
3. Output (MR): `_accompany_VB_1((_musical_JJ_1 score_NN_2), _television_program_NN_1)`



Visual Question Answering (VQA)



Is something under the sink broken?

yes	no
yes	no
yes	no

What number do you see?

33	5
33	6
33	7

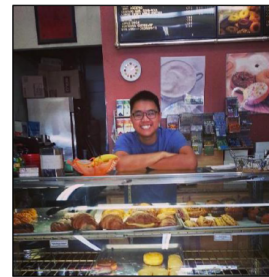


Can you park here?

no	no
no	no
no	yes

What color is the hydrant?

white and orange	red
white and orange	red
white and orange	yellow



What kind of store is this?

bakery	art supplies
bakery	grocery
pastry	grocery

Is the display case as full as it could be?

no	no
no	yes
no	yes

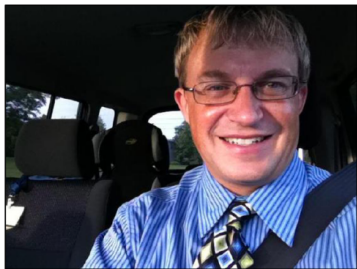


How many bikes are there?

2	3
2	4
2	12

What number is the bus?

48	4
48	46
48	number 6



Does this man have children?

yes	yes
yes	yes
yes	yes

Is this man crying?

no	no
no	yes
no	yes



Has the pizza been baked?

yes	yes
yes	yes
yes	yes

What kind of cheese is topped on this pizza?

feta	mozzarella
feta	mozzarella
ricotta	mozzarella



How many pickles are on the plate?

1	1
1	1
1	1

What is the shape of the plate?

circle	circle
round	round
round	round

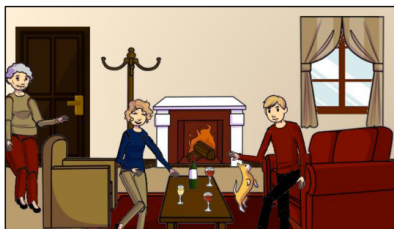


What does the sign say?

stop	stop
stop	stop
stop	yield

What shape is this sign?

octagon	diamond
octagon	octagon
octagon	round

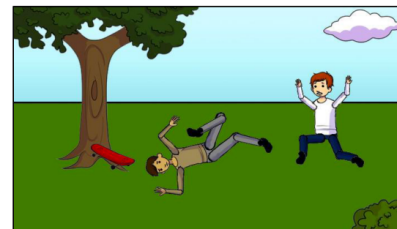


How many glasses are on the table?

3	2
3	2
3	6

What is the woman reaching for?

door	handle	fruit
glass	glass	glass
wine	wine	remote



Do you think the boy on the ground has broken legs?

yes	no
yes	no
yes	yes

Why is the boy on the right freaking out?

his friend is hurt	ghost
other boy fell down	lightning
someone fell	sprayed by hose

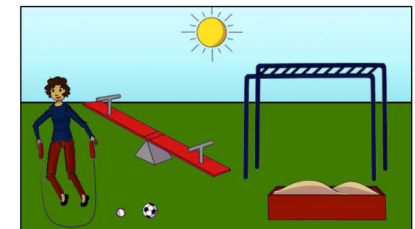


Are the kids in the room the grandchildren of the adults?

probably	yes
yes	yes
yes	yes

What is on the bookshelf?

nothing	books
nothing	books
nothing	books



How many balls are there?

2	1
2	2
2	3

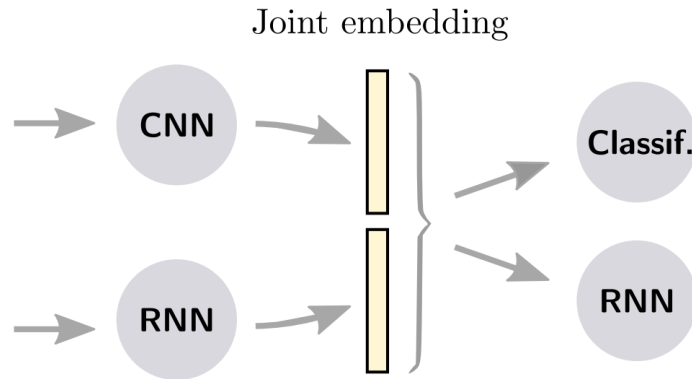
What side of the teeter totter is on the ground?

right	left
right	left
right side	right side

Architectures in VQA



What's in the background ?



mountains
sky
clouds
...

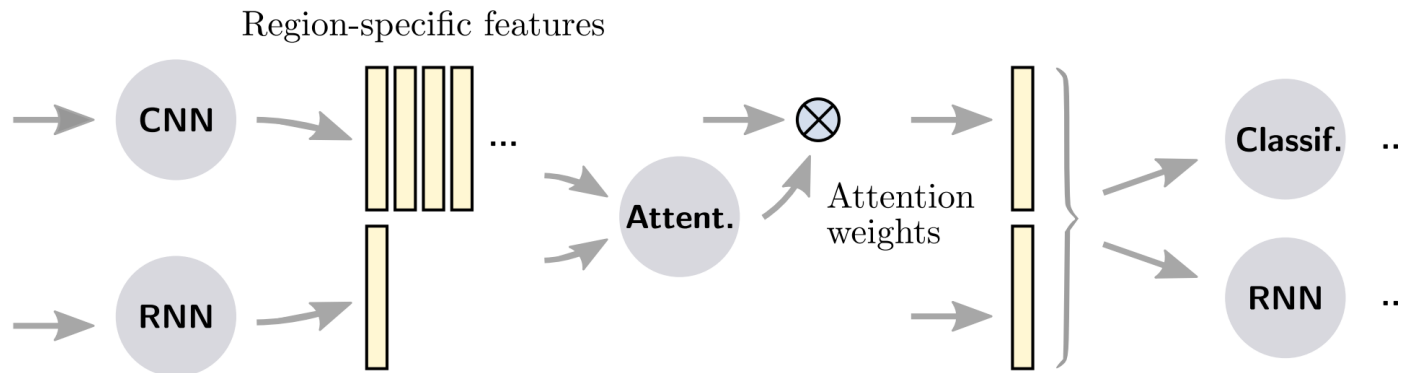
Top answers in a predefined set

Variable-length sentence generation

A snow covered mountain range

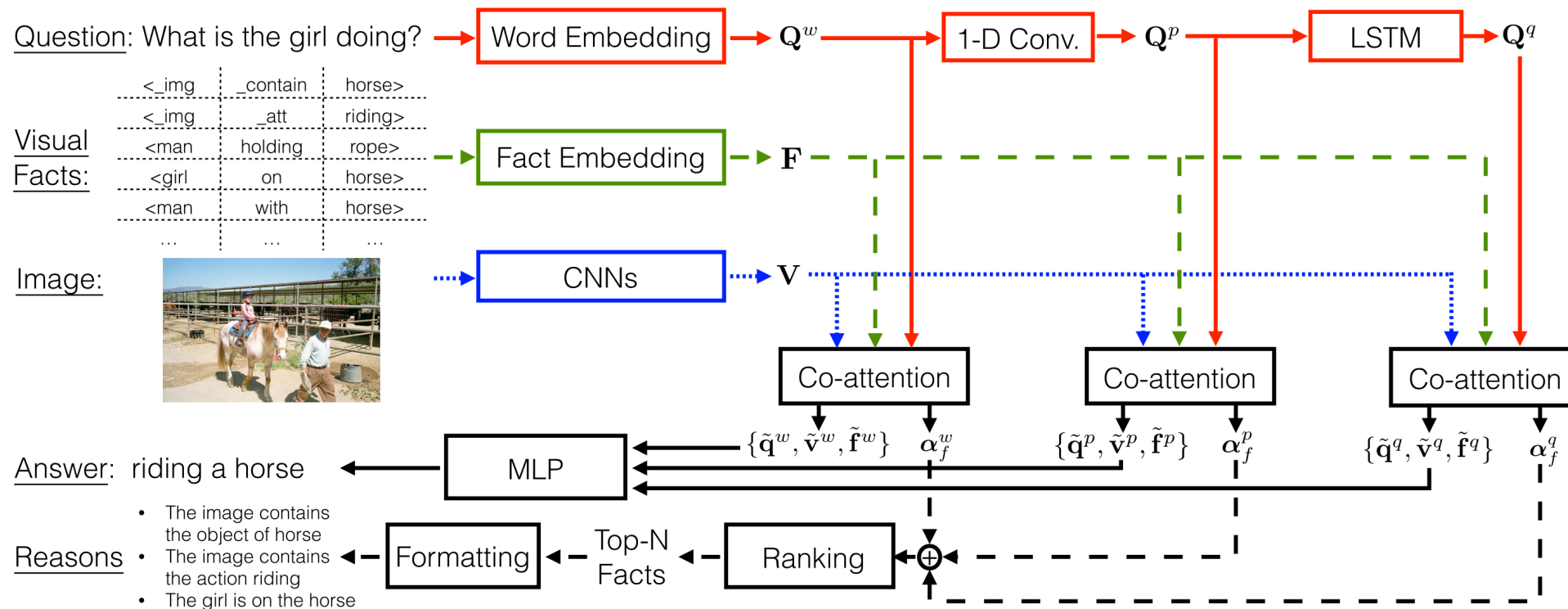


What's in the background ?



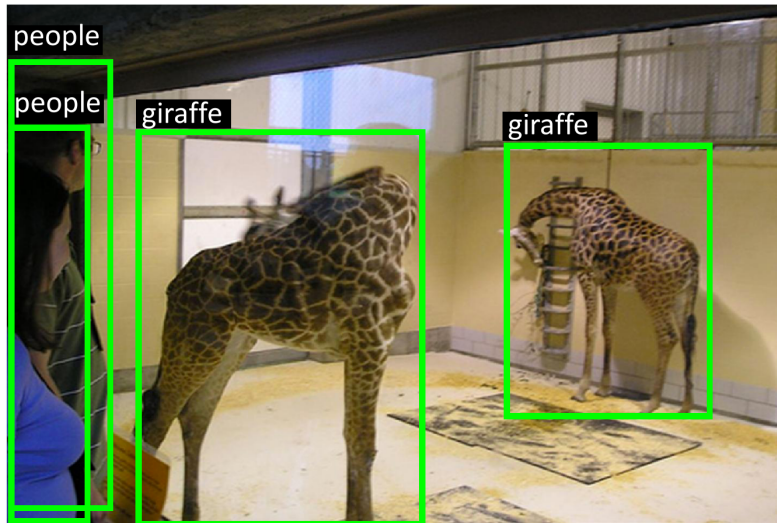
The VQA-Machine: Learning How to Use Existing Vision Algorithms to Answer New Questions

Authors: Peng Wang, Qi Wu, Chunhua Shen, Anton van den Hengel



Explicit Knowledge-based Reasoning for VQA

Authors: Peng Wang, Qi Wu, Chunhua Shen, Anton van den Hengel, Anthony Dick

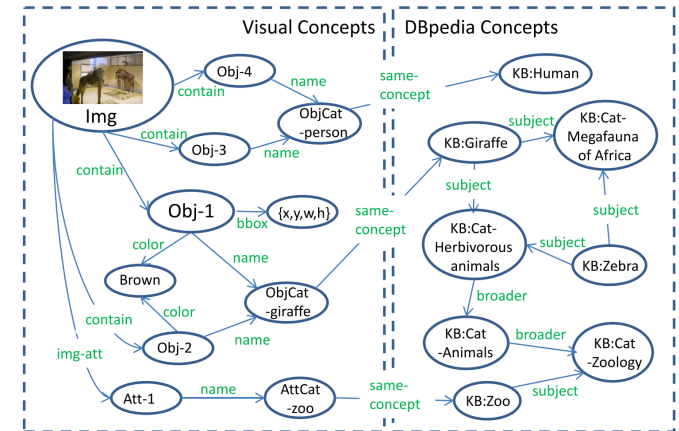


Attributes:

glass
house
room
standing
walking
wall
zoo

Scenes:

museum
indoor



Visual Question: How many giraffes in the image?

Answer: Two. **Reason:** Two giraffes are detected.

Common-Sense Question: Is this image related to zoology?

Answer: Yes. **Reason:** Object/Giraffe --> Herbivorous animals --> Animal --> Zoology; Attribute/Zoo --> Zoology.

KB-Knowledge Question: What are the common properties between the animal in this image and the zebra?

Answer: Herbivorous animals; Animals; Megafauna of Africa.

