OBEliSK | Novel Knowledgebase of Object Features and Exchange Strategies

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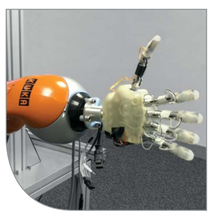
Introduction

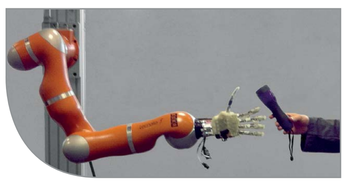
Our goal comprises the design and development of a knowledgebase about the domain elements involved in the action of exchanging common objects between humans and robotic agents. The main purpose of this knowledgebase is to model and transfer the acquired knowledge from human-human object exchange experiments to a robotic system, in order to achieve a fluent interaction between human and robotic agents.

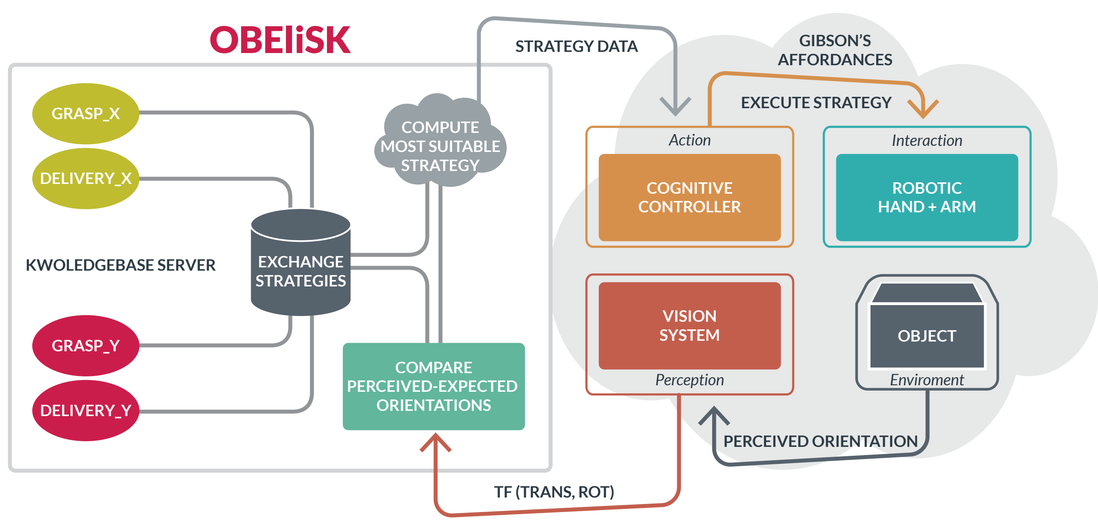


Object perception

For each object, its 3-D model is captured using a Kinect sensor.

Then, each one is processed and a set of partial views is extracted for being used during feature descriptors computation and subsequent classification.

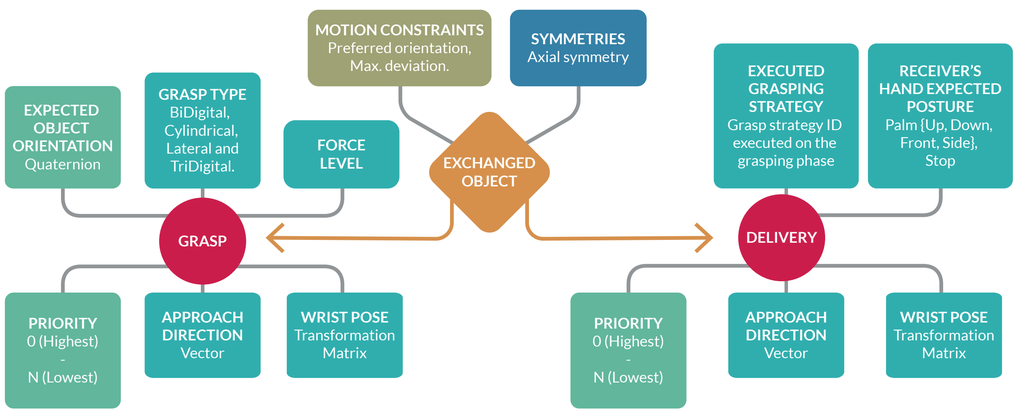




Object handling

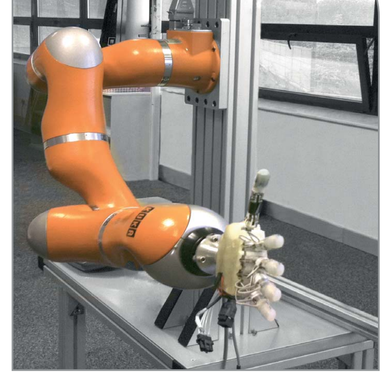
Object affordances

The taken approach is related to the concept of affordances and based on the idea of categorizing objects based on how they are used, associating each object to a set of grasp postures and delivery strategies, defining different ways in which the robot can handle it.



Grasping phase

The set of grasps to be considered relies on the automatic grasping capabilities provided by the IH2 Azzurra robotic hand (Prensilia SRL, Italy). Based on Cutkosky's grasp taxonomy, the modelling process using OWL is made straight from that one to our model, thanks to the hierarchical shape and the classification-oriented vocabulary. Each grasp instance represents an object-specific grasping configuration.



Delivery phase

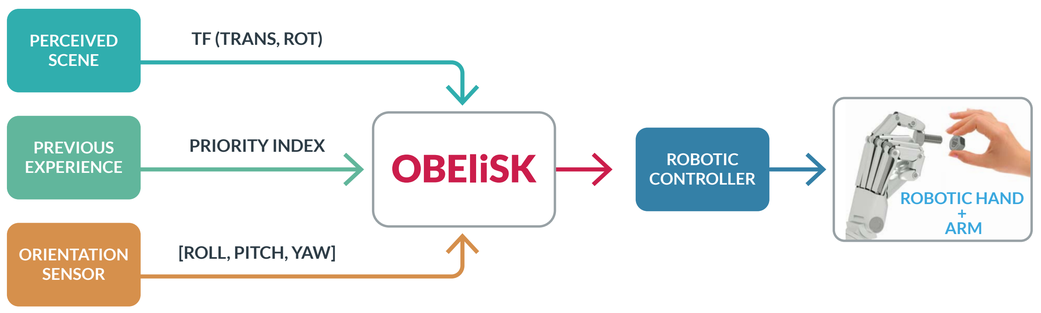
For improving the knowledgebase contribution to the whole project, the initial conception of a grasping database was extended to a fully-featured handling knowledgebase. The control system has to be provided with relevant data about the object handover, being capable to deliver the previously grabbed object to the recipient in a fluent and natural way.

Learning & Reasoning

For inferring the most suitable strategy, adapted to the current interaction environment, the following inputs are collected:

- Scene perception → *Segmentation, Detection, Tracking & Estimation*
- Experience from previous interactions → *Feedback from the cognitive controller*
- Object-embedded orientation → *Custom sensor solution (R.U.Robots, UK)*

Based on this data, the OBEliSK inference engine proposes an exchange strategy to be executed by the robotic setup.



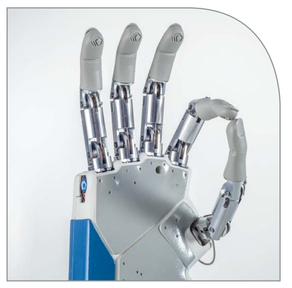
Knowledgebase data management

Data processing and storage in this kind of databases is not trivial. Having a large amount of information and a defined ontology, it is mandatory to fully respect the relational integrity restrictions between entities and their properties. With the aim of ease this task, a utility has been developed focused on offering the simplest way to manage the knowledgebase contents, consisting of a web-application acting as interface between the user and the triple store where the ontology data is saved.

CONCEPT	GRASPING PH.	DELIVERY PH.
Object involved in the action	✓	✓
Grasp type, from taxonomy primitives	✓	✗
Expected object orientation/receiver's hand posture	✓	✓
Grasp strategy previously executed	✗	✓
Grasp force level to be reached by the fingers	✓	✗
Object's grab/release approach direction	✓	✓
Robotic hand wrist pose	✓	✓
Strategy selection preference (priority)	✓	✓

Conclusions

Our robotic handling knowledgebase was designed by means of semantic-ontological technologies, providing an interesting and innovative approach.



Regarding the communication and feeding of data from the handling knowledgebase to the robotic controller, the developed techniques, provided in a structured and complete interface of query services, allows the system to adapt the strategy selection to the specific situation, while taking advantage from the continuous learning process that improves the algorithm in charge of selecting the most advisable strategy for grasping, handling and delivering each object.

Also, the input provided from project's partners from their studies on human to human handover process, motion capture trials and experimental reports were highly valuable contributions to the knowledgebase design, development, population and subsequent refinement.

ECCV '14 Zürich, September 6-12th, 2014
EUROPEAN CONFERENCE ON COMPUTER VISION

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September 7, 2014 · Zurich - Switzerland

This work was supported by the CogLaboration project within the Seventh Framework Programme of the European Union, Cognitive Systems and Robotics under grant agreement n° 287888.