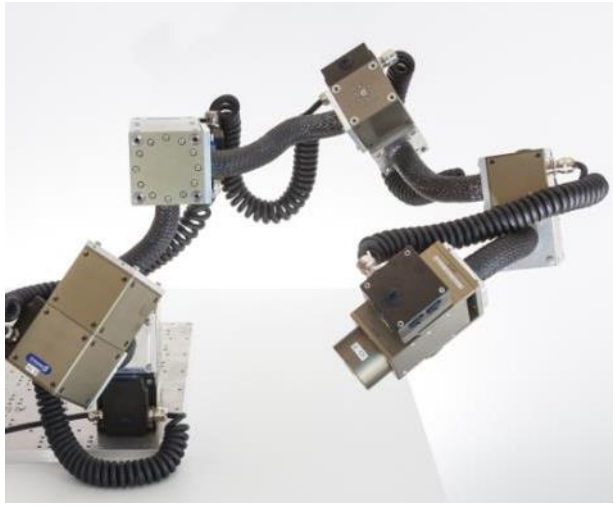
JOANNEUM RESEARCH ROBOTICS

YuMi come and play with me! A Collaborative Robot for piecing together a Tangram Puzzle

ROBOTICS – Institute for Robotics and Mechatronics

- R&D partner with know-how in the scientific & engineering foundations of robotics and mechatronics
- R&D at the interface between university-level basic research, applied research and advanced robotic system's integration
- R&D and consultancy for robot- and functional safety
- Robot system's safety certification
- Research Focuses:
  - Robot Mechanisms and Mechatronic Systems
  - Robot Systems
  - Cognitive Robotics
  - Robot Safety



Project Motivation

- **Current Standard Industrial Robotics:**
  - Robots perform clearly specified, pre-defined, repetitive motions in constrained environment
  - No or very limited abilities to perceive the environment and adapt to it
  - Operated behind safety fences
  - High investment costs
  - Financial benefits only for large batch sizes

http://www.theoldrobots.org/images3/manufacturing7.JPG

- **Collaborative Robotics:**
  - Combine strengths of robots (endurance, precision, etc.) and humans (perceptual and cognitive apilities, etc.)

Why collaborative?

„The action of working with someone to produce or create something“

- 4 type of collaborative features
  - Safety-rated monitored stop
  - Hand-guiding
  - Speed and separation monitoring
  - **Power and force limiting**

Challenges

- Machine perception
- Sensitive redundant kinematic manipulation
- Dynamic adaptive task planning
- Human robot interaction and information excange
- Human state evaluation
- Safety standards

„CollRob“ - Collaborative Robotics

Levels of H-R Interaction

Category	A	B	C	D	E	F
Umbrella Term	encapsulation	H-R co-existence	static H-R collaboration	dynamic H-R collaboration	static / dynamic R-R collaboration	static / dynamic H-R-R collaboration
Interaction-Level	interaction-free operation	safety stop	static collaboration	dynamic collaboration	static / dynamic collaboration	static/dynamic collaboration
Actors	robot	human+ robot	human+ robot	human+ robot	2 robots	2 robots + human
Temporal Dependence	independent	interrupt	sequential	simultaneous	sequential/ simultaneous	sequential/ Simultaneous
Spatial Dependence	separated	separated	shared	shared	shared	Shared
Human-Robot Contact	none	rudimentary	pronounced	comprehensive	n.a.	pronounced / comprehensive

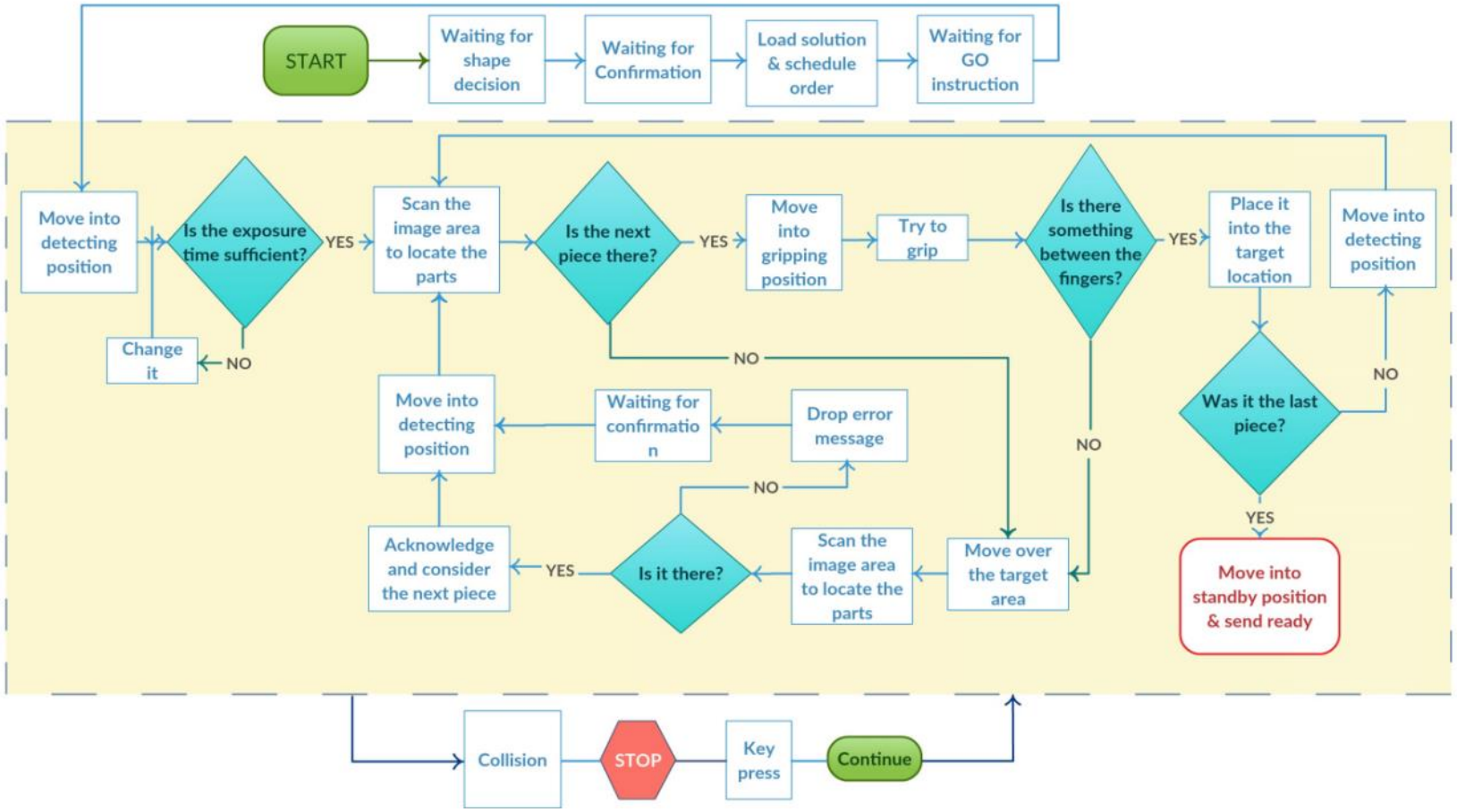
One set of use cases had to be defined -> Solving a Tangram puzzle

ABB IRB14000 or YuMi Main features

- Inherently safe
  - Eliminated pinch points
  - Speed limited motors
  - Lightweight and padded 7 DoF dual arms
  - Effective payload with the standard gripper around 250 gram
  - Reconfigurable gripper modules (servo, vision, compressed air)

Video

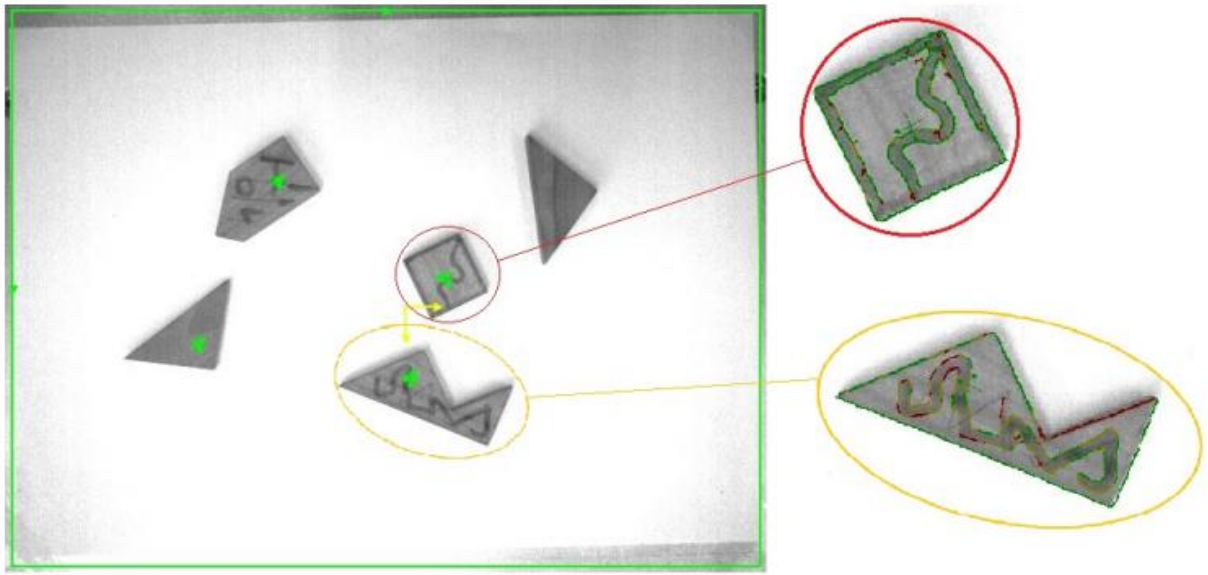
Technical Details



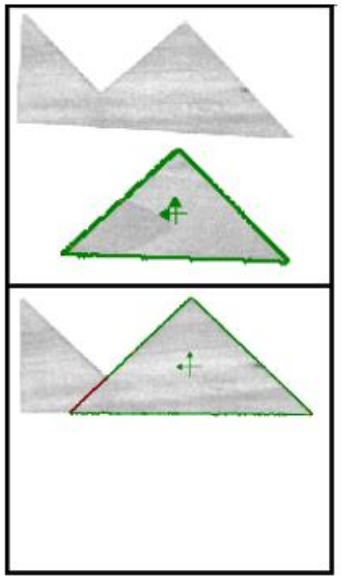
Drawbacks

- Too short, only 5 pieces
- Hardware restrictions (vision)
- Human wasn‘t so precise
- They accidentally moved away pieces, resulted (robot) finger braking
- Player must know the behavior of the program

Vision



(a) The located puzzle pieces with the pattern and their object frames

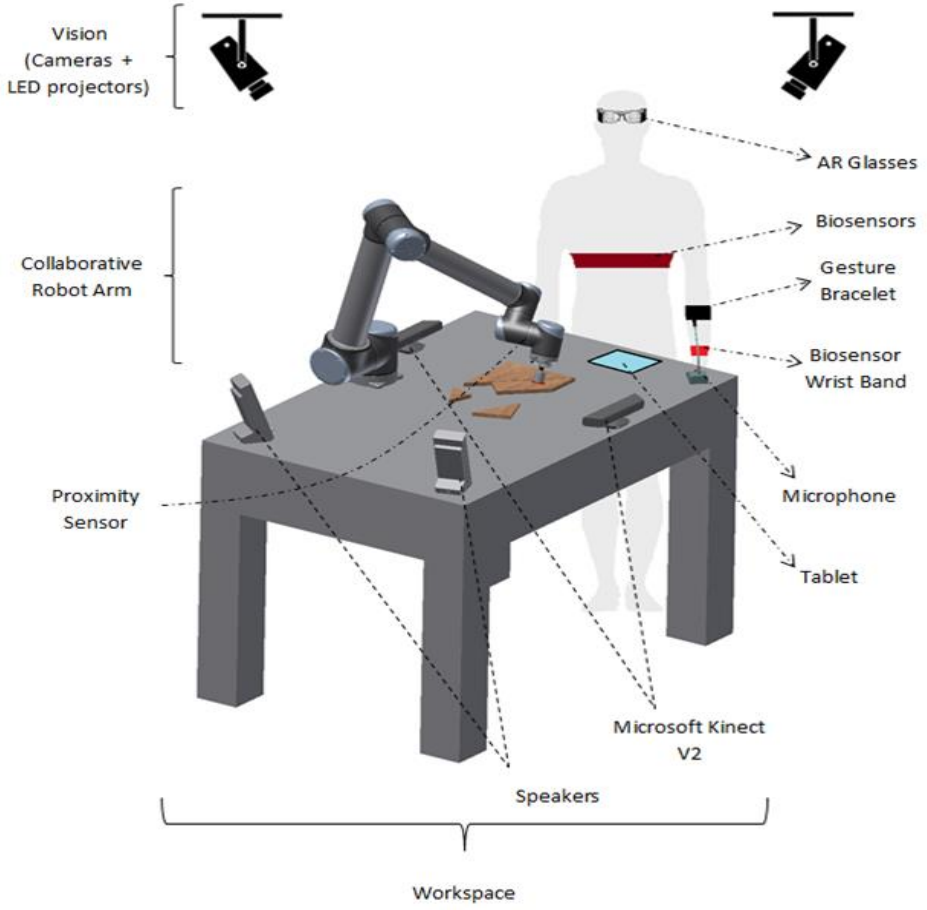


(b) Mismatch of the pieces

Conclusions, Extensions

- Features in future (speech recognition, advance learning, etc.)
- In industry small part assembly, pick and place operation
- Rehabilitation purposes
- Entertainment
- (Human factor study: part of a program was used for this purpose)

Human factor study



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Results

Method	Time
One hand – 5 vision jobs	78 s
Two hand – 5 vision jobs	64 s
One hand – 1 vision job	59 s
Two hand – 1 vision job	42 s