diver's behaviour and physical state

CADDY

Cognitive Autonomous Diving Buddy

SEVENTH FRAMEWORK PROGRAMME

http://www.caddy-fp7.eu/

Key facts:

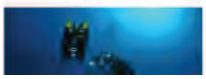
FP7-ICT Cognitive Robotics STREP with 7 partners

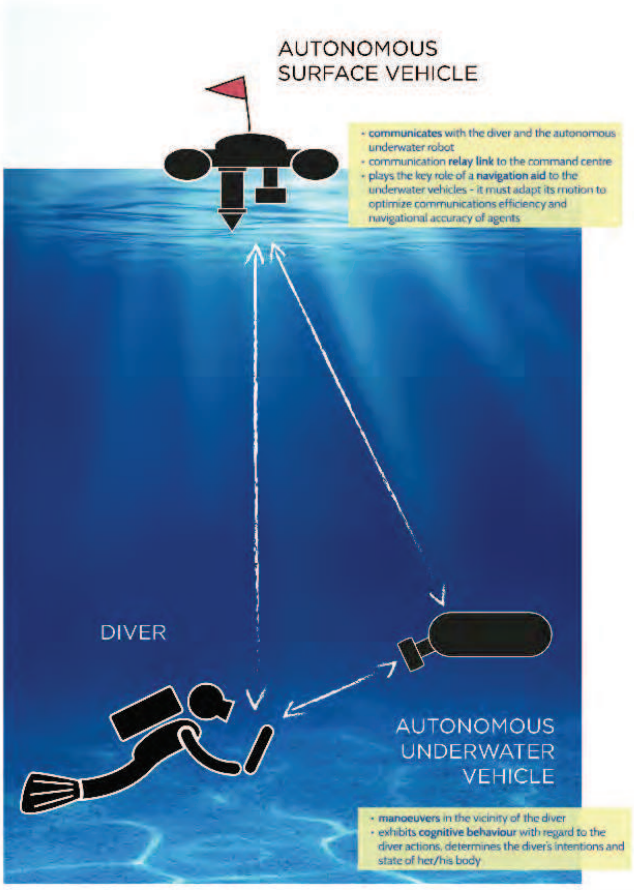
EU contribution: €3,7 million, (FER €709,000)

Duration: 36 months, starting 01/01/2014

Coordinator: UNIZG-FER

FER · Consiglio Nazionale delle Ricerche · IST LISBOA · JACOBS UNIVERSITY · universität wien · Newcastle University · DAN EUROPE





What?

Set up symbiotic links between a human diver and a set of companion autonomous robots (underwater and surface).

How?

By developing a multicomponent, highly cognitive robotic system capable of learning, interpreting, and adapting to the diver's behaviour and physical state

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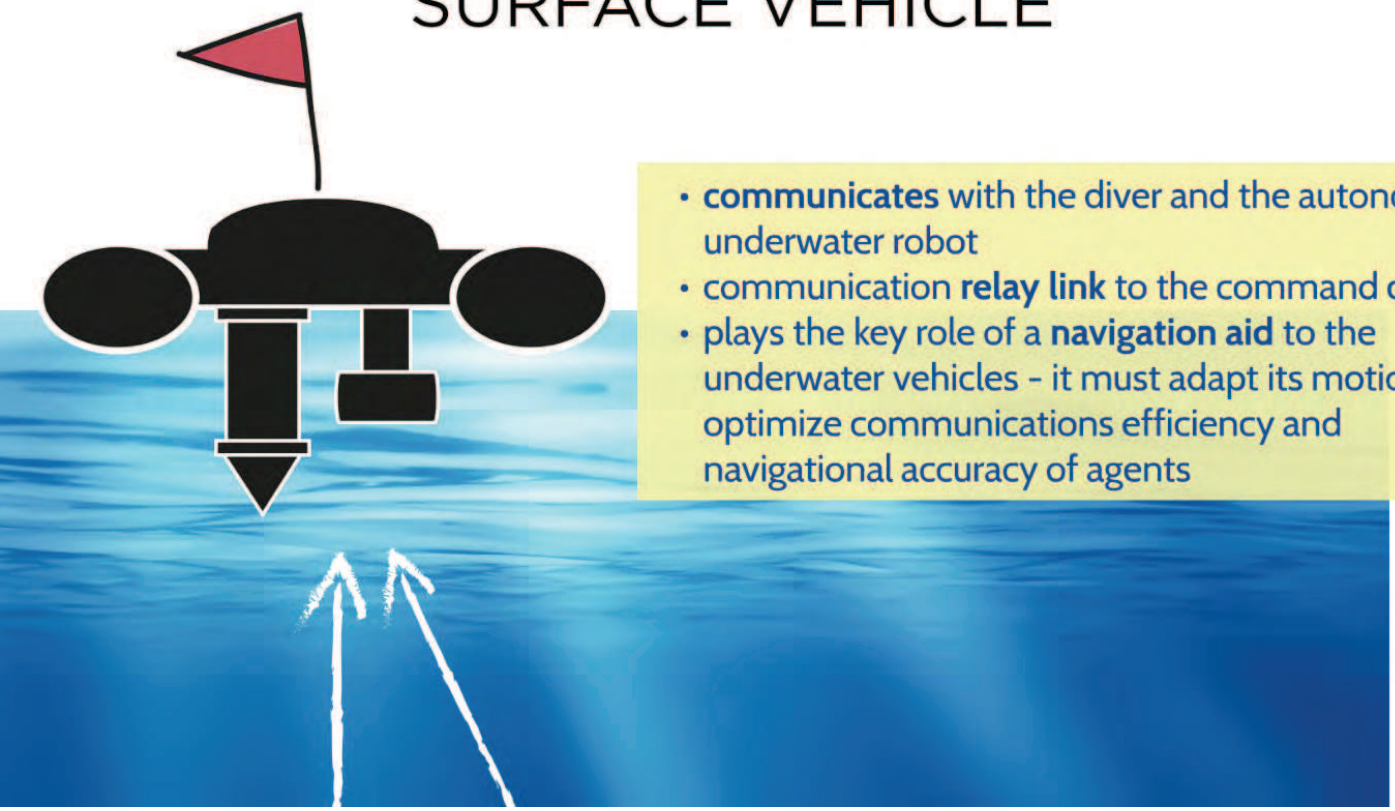
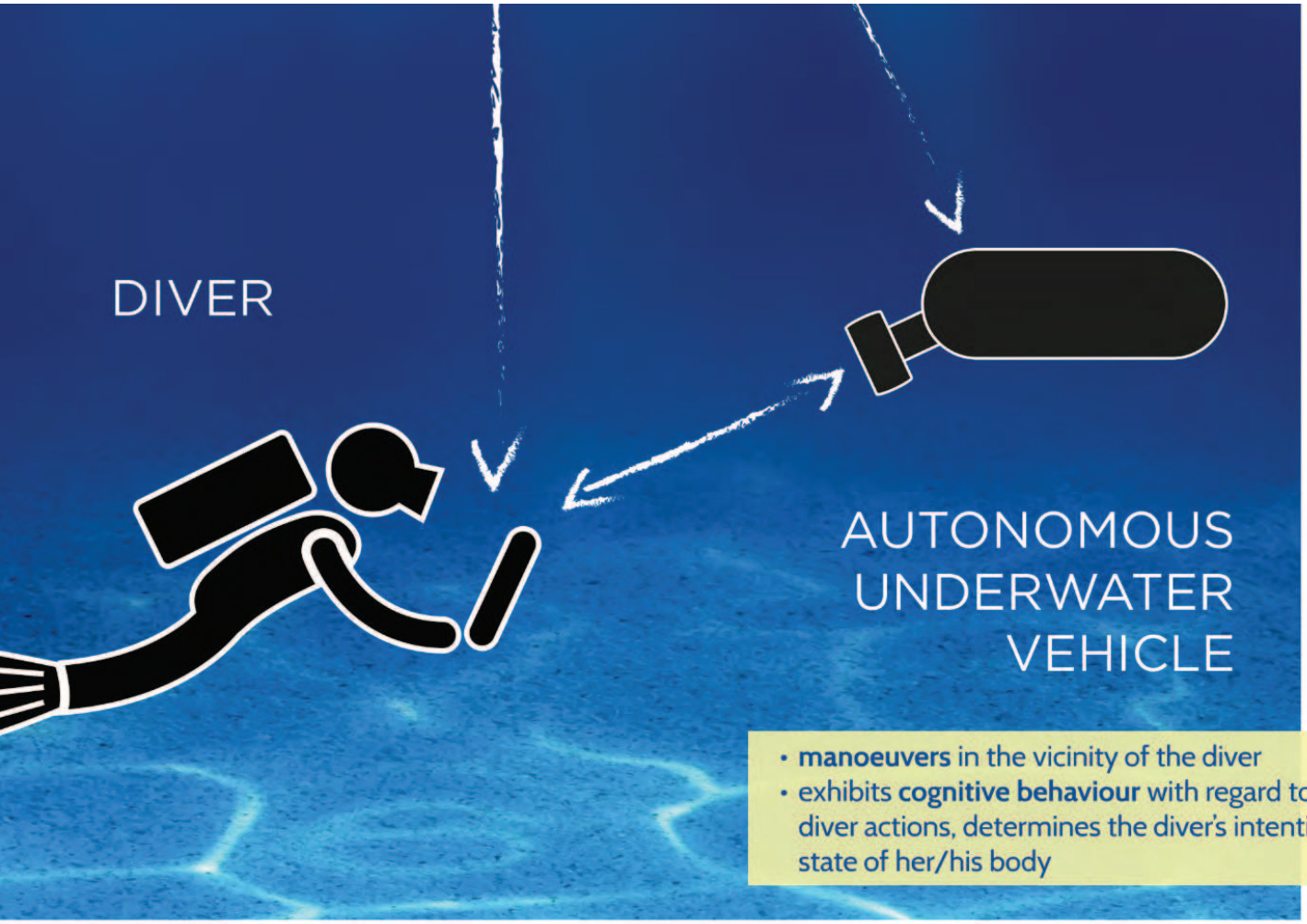
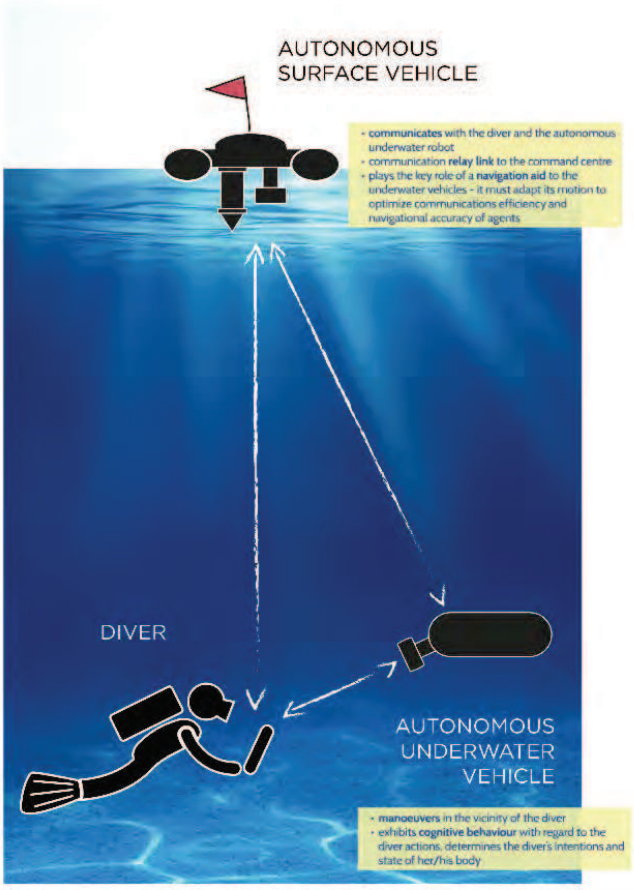
AUTONOMOUS SURFACE VEHICLE



- **communicates** with the diver and the autonomous underwater robot
- communication **relay link** to the command centre
- plays the key role of a **navigation aid** to the underwater vehicles - it must adapt its motion to optimize communications efficiency and navigational accuracy of agents


DIVER
AUTONOMOUS
UNDERWATER
VEHICLE
• **manoeuvers** in the vicinity of the diver
• exhibits **cognitive behaviour** with regard to the diver actions, determines the diver's intentions and state of her/his body



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Diver safety

- more than 50% of accidents happen while the divers were not accompanied.
- loss of conscience, N2 narcosis

Surveying the seabed
- the S&R mission -

- Task: search a specified underwater area and recover one or more objects.
- Setting up transect rope (time-consuming, extra divers)
- diver then follows the line

Challenging UW operations
- archaeological site -

- multiple rectangular frames placed for site referencing
- measuring, sketching, taking photos
- Diver may decide to change the mission.

RSITY universitat wien Newcastle University E

- cooperates with diver
- guides the diver along predetermined transects allowing her/him to execute the most productive tasks

- enables precise navigation to the site via an optimal route


dive guide
• **guides** (upon request) the diver from one spot to another, along a predefined search path,
• **steers the diver safely** to an appropriate point at the surface
• acts as an intelligent **communication router** in situations where the diver loses line-of-sight to the surface vessel.


dive observer
• **observes** the diver at all times
• **interprets** diver's **behaviour** and **symbolic gestures** communicated by the diver.
• manoeuvres safely around the diver in order to assume the **best viewpoint** for observation;

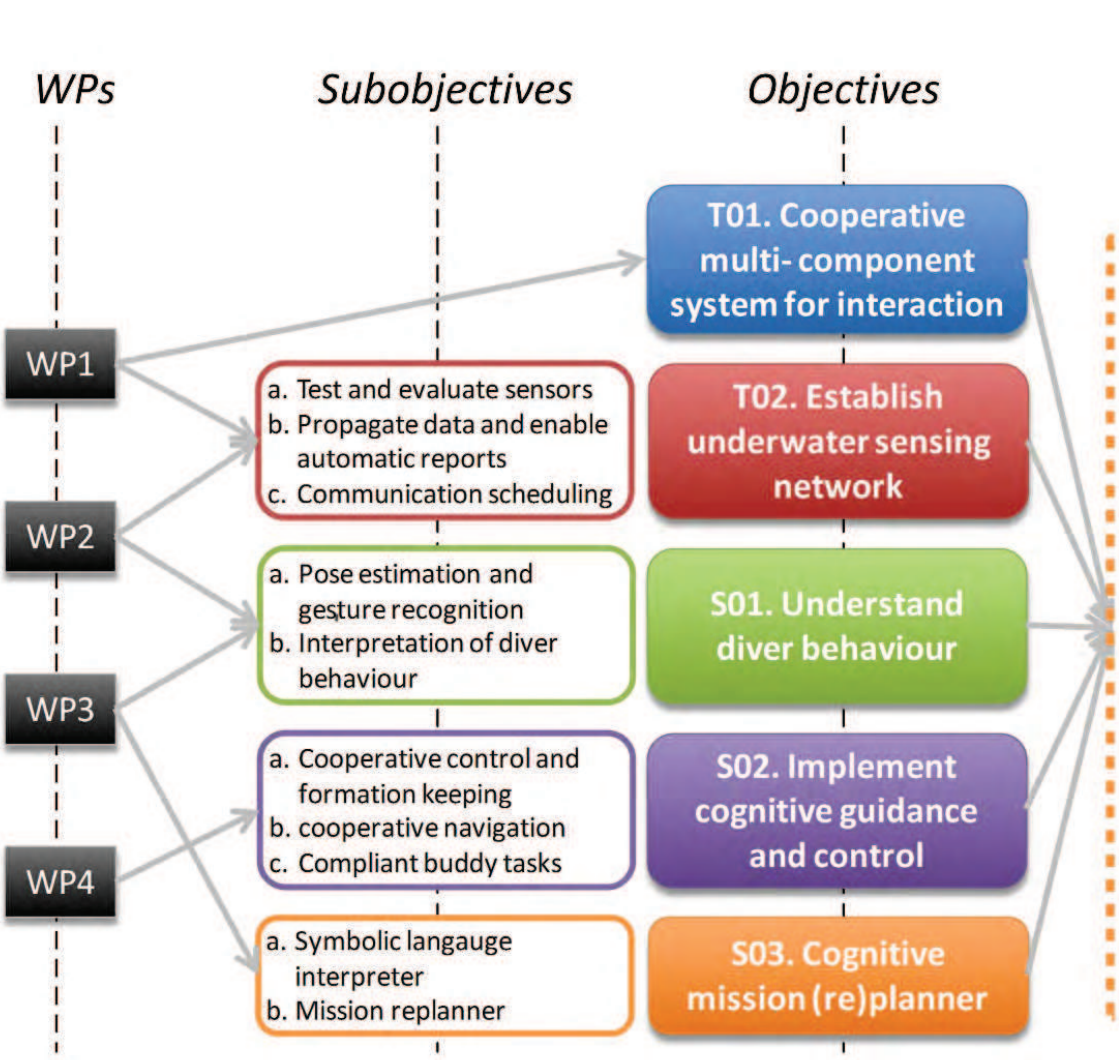

dive slave
• hovers over a spot indicated by a laser beam and **takes photos** of the location
• **follows** the diver
• performs a **mosaic** of an indicated area,
• **illuminates** a site from different angles upon request from the diver,
• **carries** a payload with tools and equipment.

- cooperates with diver
- guides the diver along predetermined transects allowing her/him to execute the most productive tasks

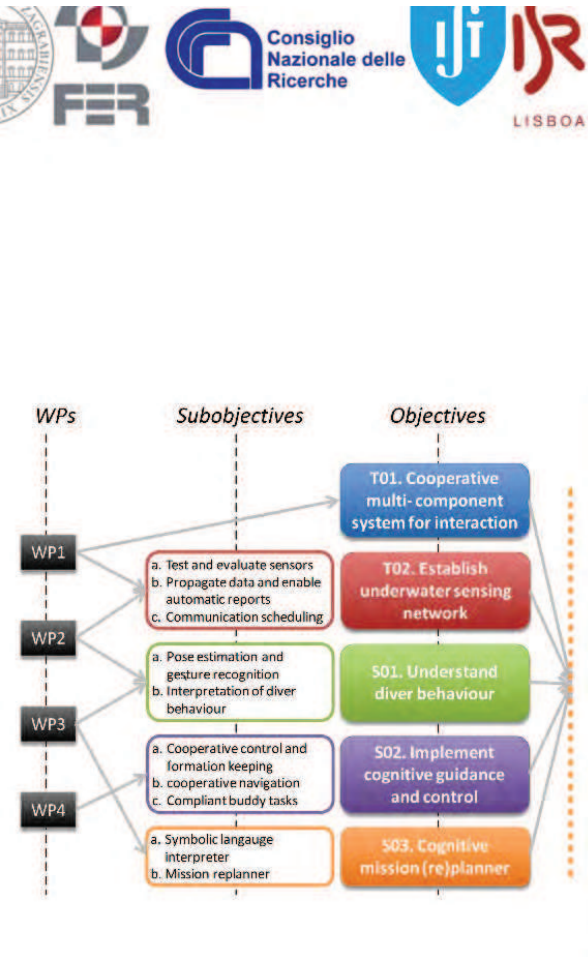
- enables precise navigation to the site via an optimal route

- close to the diver
- interprets diver behaviour
- detect anomalies
- promptly reports cmnd. centre

- Interprets symbolic commands
- executes compliant tasks (photo s, videos, illumination)
- Reports mission replanning


WPs
Subobjectives
Objectives
WP1
WP2
WP3
WP4
a. Test and evaluate sensors
b. Propagate data and enable automatic reports
c. Communication scheduling
a. Pose estimation and gesture recognition
b. Interpretation of diver behaviour
a. Cooperative control and formation keeping
b. cooperative navigation
c. Compliant buddy tasks
a. Symbolic langauge interpreter
b. Mission replanner
T01. Cooperative multi- component system for interaction
T02. Establish underwater sensing network
S01. Understand diver behaviour
S02. Implement cognitive guidance and control
S03. Cognitive mission (re)planner


dive guide
dive observer
dive slave



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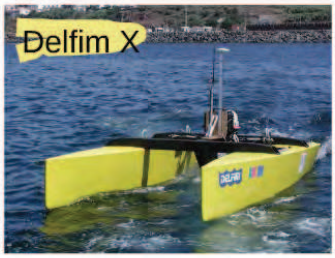
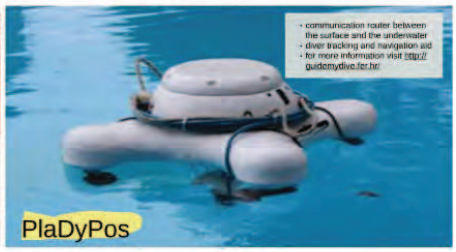
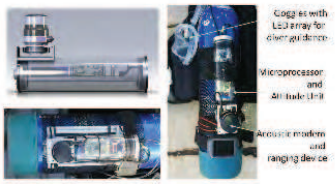
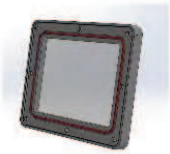
Surface segment

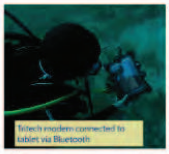


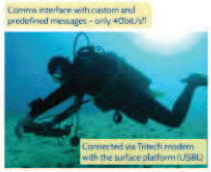


Linking the diver

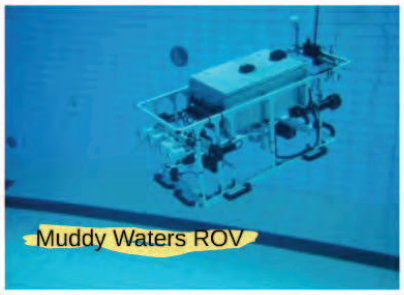


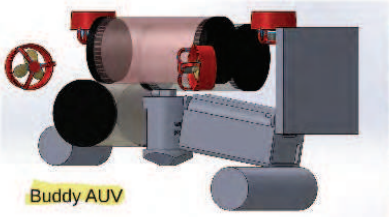


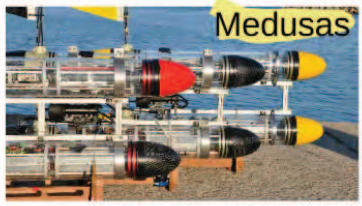


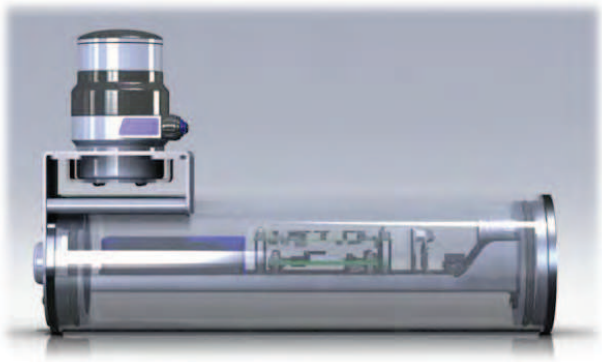


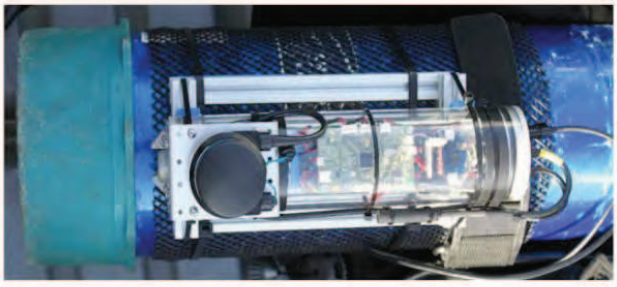
Underwater segment







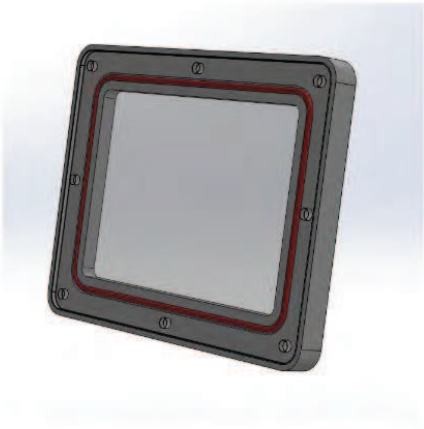




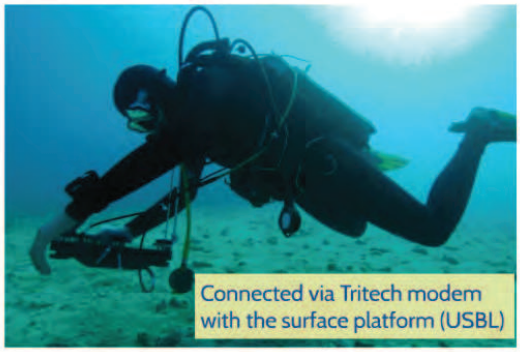
Goggles with LED array for diver guidance

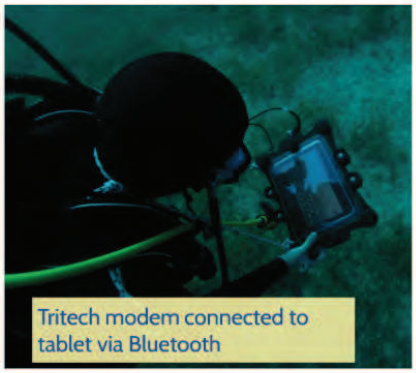
Microprocessor and Attitude Unit

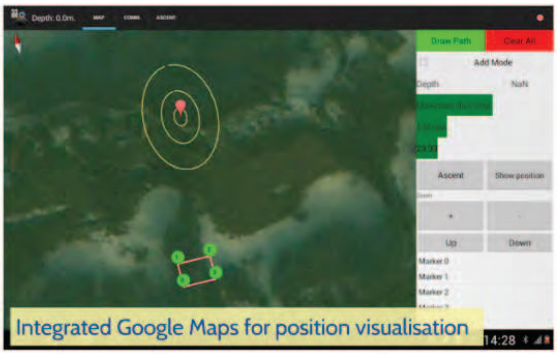
Acoustic modem and ranging device



Comms interface with custom and predefined messages – only 40bit/s!!





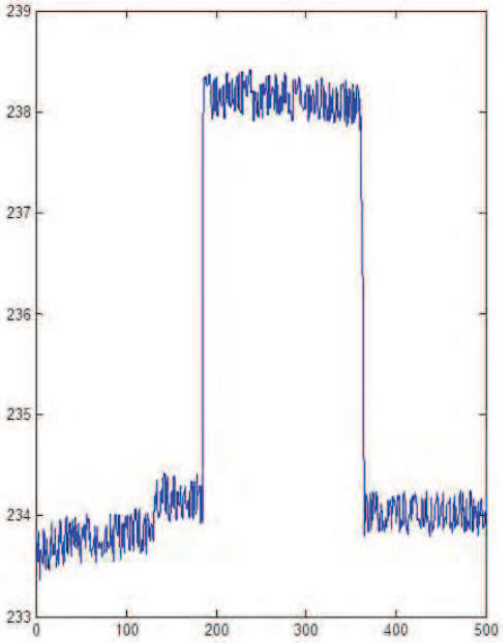


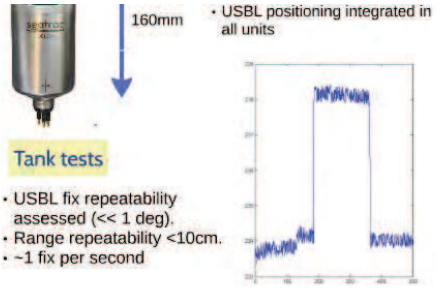
New miniature modem/USBL to replace Micron

- 100bps data rate
- more efficient protocols (1-2kbps by end 2014)
- USBL positioning integrated in all units

Tank tests

- USBL fix repeatability assessed (<< 1 deg).
- Range repeatability <10cm.
- ~1 fix per second





2
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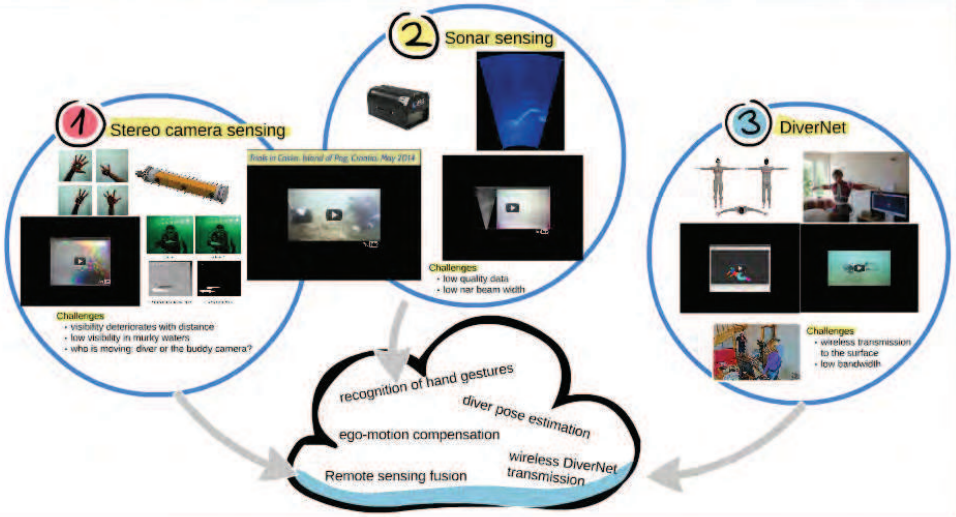
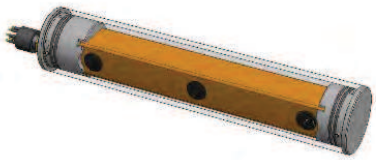
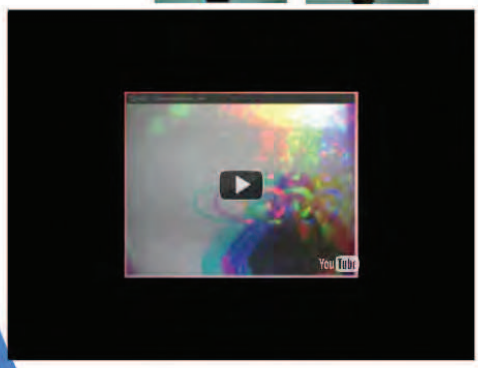


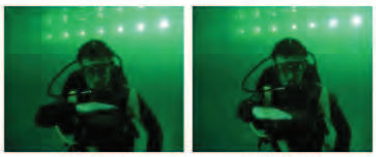
Recognition of hand gestures

Pose int

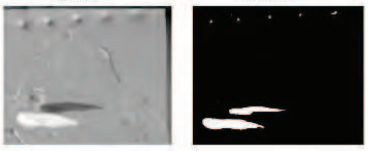
1 Stereo camera sensing



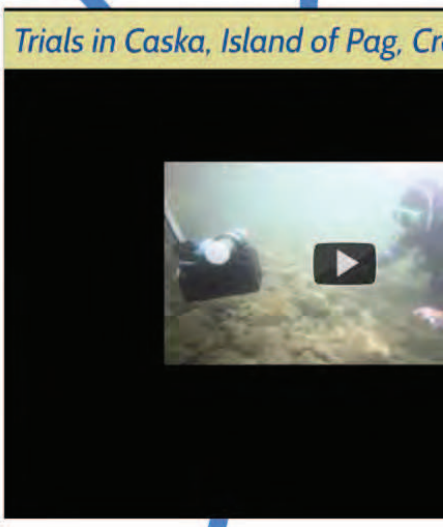




(a) frame 1 (b) frame 2



(c) Alignment and difference image. (d) Segmentation result.



Challenges

- visibility deteriorates with distance
- low visibility in murky waters
- who is moving: diver or the buddy camera?

2 Sonar sensing

ng

n Caska, Island of Pag, Croatia, May 2014

Challenges

- low quality data
- low nar beam width

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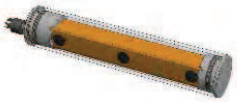

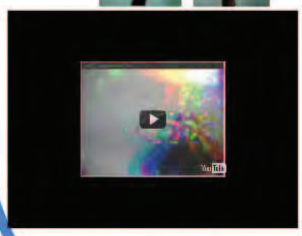

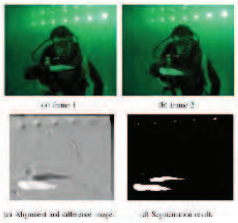

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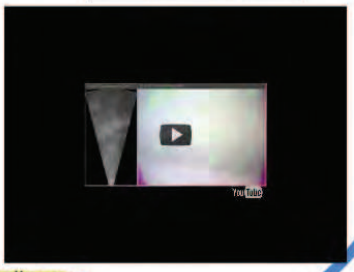


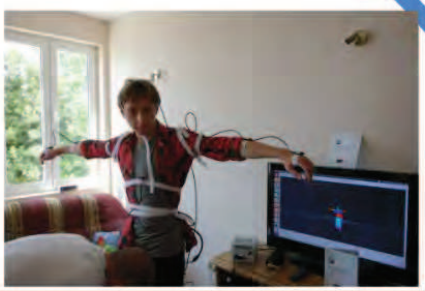
Challenges
- low quality data
- low nar beam width

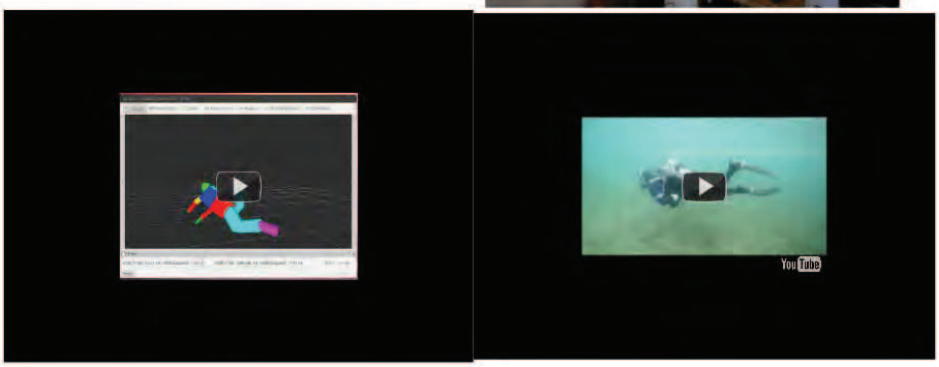
recognition of hand gestures

diver pose estimation

ego-motion compensation

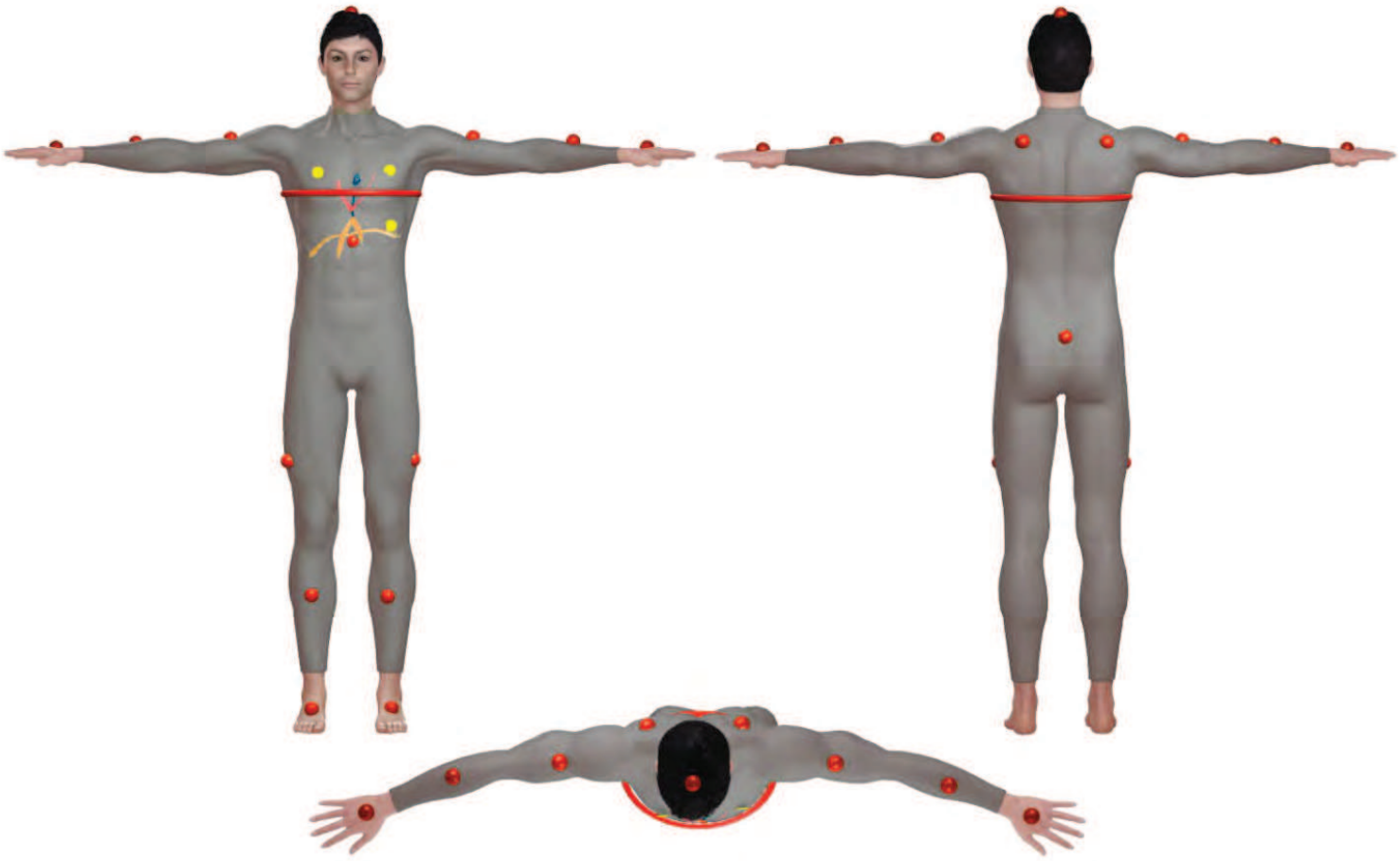
3 DiverNet





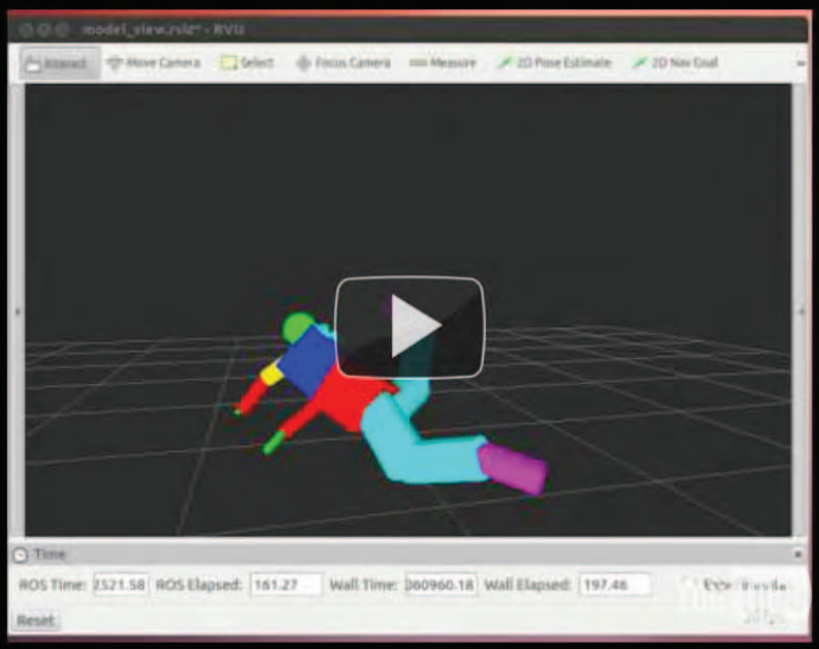
Challenges

- wireless transmission to the surface
- low bandwidth

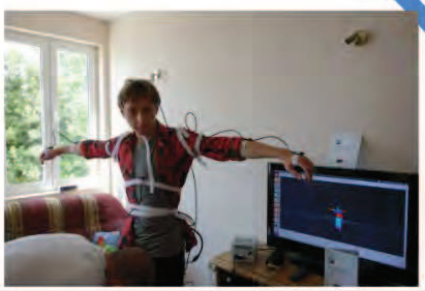


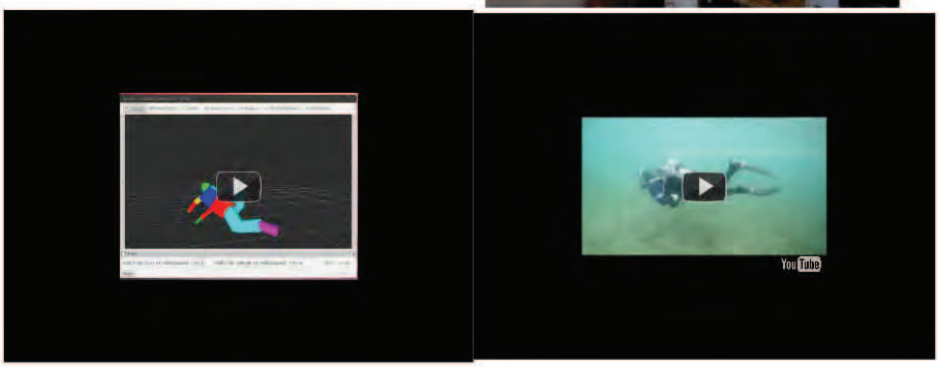

CADDY
CADDY


YouTube


Interact
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Nav Goal
Time
ROS Time: 2521.58
ROS Elapsed: 161.27
Wall Time: 1560960.18
Wall Elapsed: 197.46
Reset

3 DiverNet





Challenges

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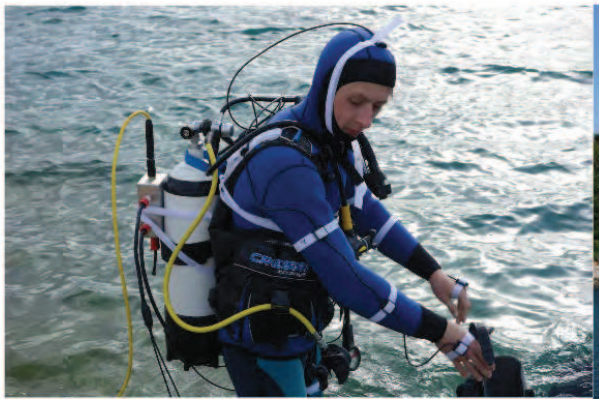
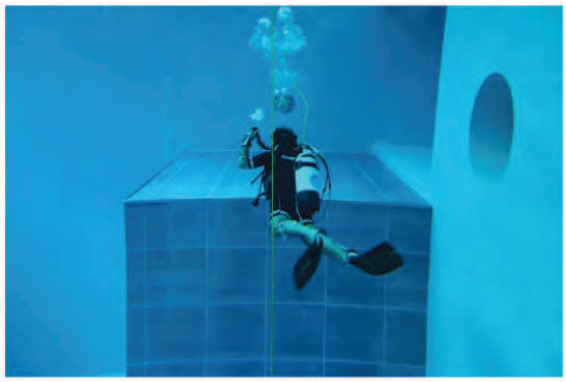
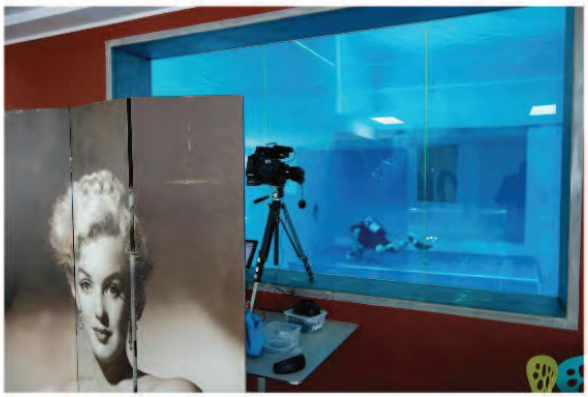
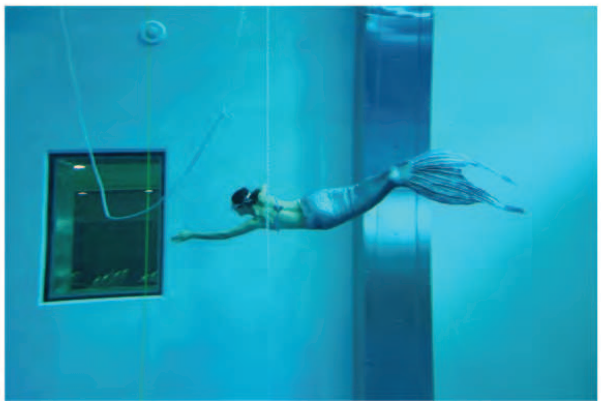
Trials in Caska Island Pag, Croatia May 2014

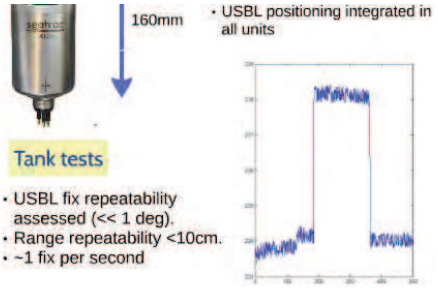




Trials in Y-40 pool
Padova, Italy
June 2014







2
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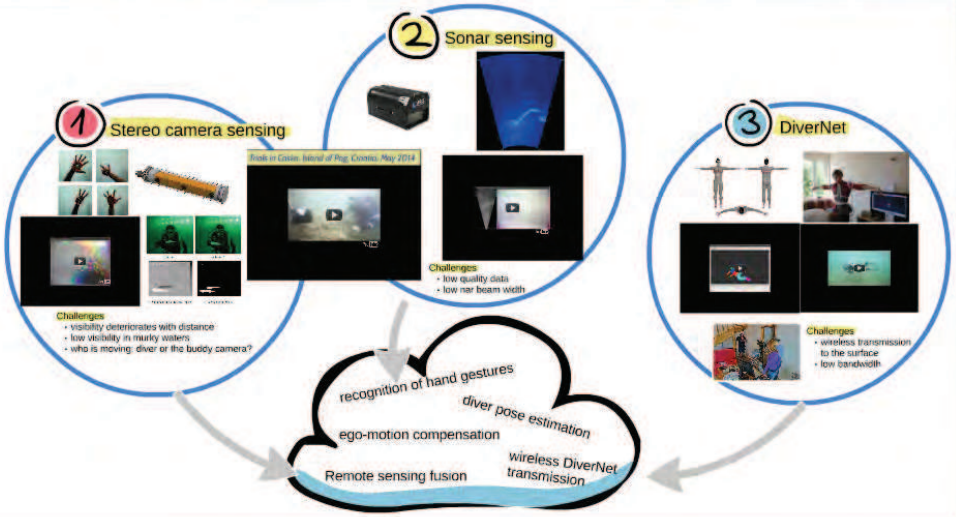
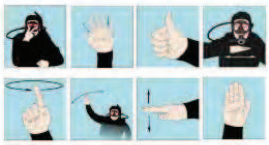
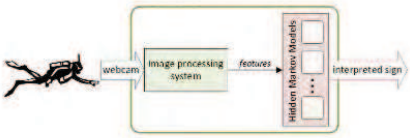


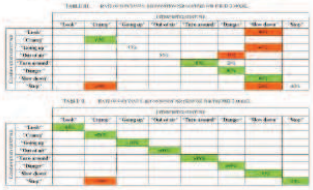
Recognition of hand gestures

Pose int

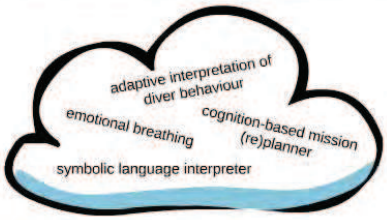
Recognition of hand gestures







WP3 Understanding the diver



Pose interpretation

Pose interpretation