Design of the Vision System for an Intervention-AUV

RAUVI: Reconfigurable AUV for Intervention

VISUAL: ***Vision for AUVs with Intervention Capabilities***

GOBIERNO DE ESPAÑA
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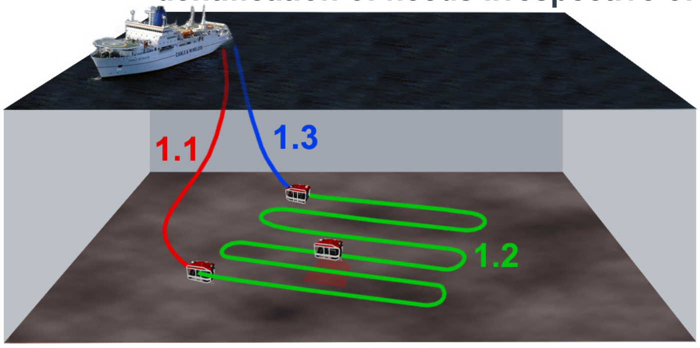
- Context: The role of vision in RAUVI project
- Imaging infrastructure
  - Options
  - Functions and structure of the vision server module
  - The harware
- Visual Odometer

Context : Role of Vision in RAUVI

- Identification of needs irrespective of schedule – scope of VISUAL in red



1.1 Launching
1.2 Survey
- capture of images with position labelling
- *visual odometer*
- *standard navigation sensors: IMU, altimeter, DVL, ...*
- *acoustic sensors*

in a sensor fusion framework (UW SLAM ?)

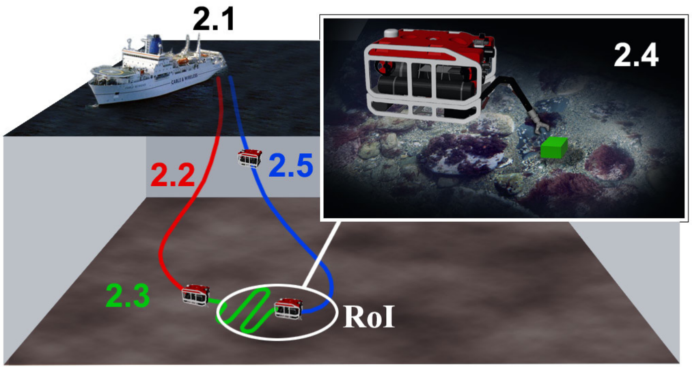
1.3 Recovery

2.1 Characterization of Intervention
- *image database management (coarse mosaic)*
- *view characterization*
- *object characterization*

2.2 Launching
2.3 Navigation to the *Region of Intervention*
- *view identification*
- *object identification*

2.4 Intervention
- *station keeping*

2.5 Recovery



Context : Tasks to implement in VISUAL

- **Study of imaging infrastructure options**
- **Capture of images with position labelling:**
  - **visual odometer**
  - acoustic positioning
  - framework for sensors fusion / visual SLAM
- **Image database / coarse mosaic generation**
- **View characterization and identification**
- **Object characterization and identification**

Imaging infrastructure

- Imaging infrastructure
  - Improve subsea image quality at a reasonable cost
  - Overcome interference of the media: attenuation and scattering

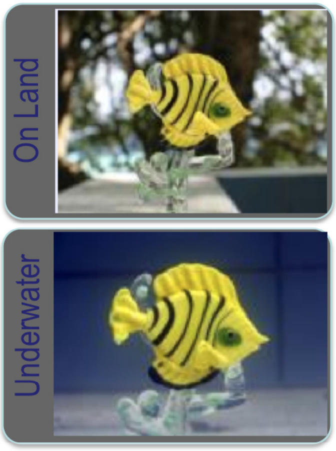
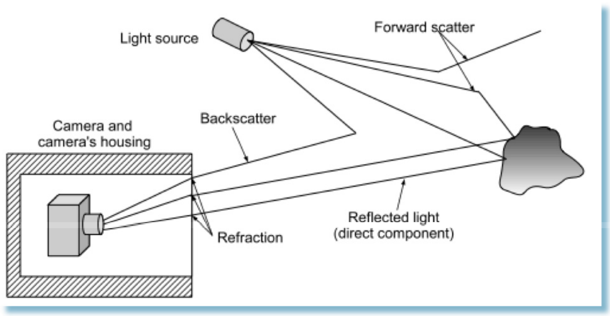
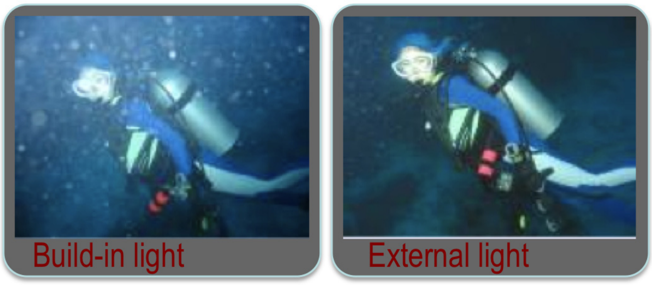
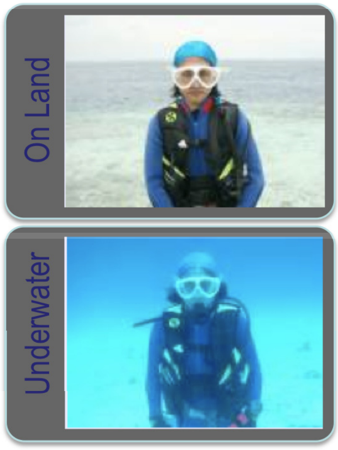


Image distortion



Marine snow effect reduction

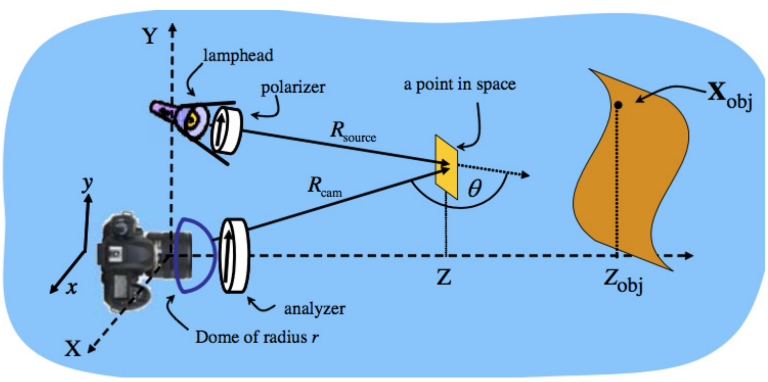




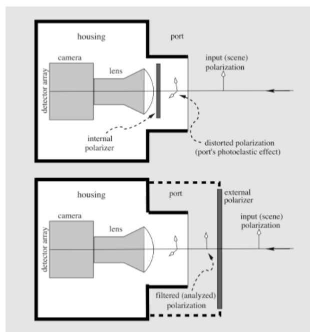
Light attenuation
(non uniform)

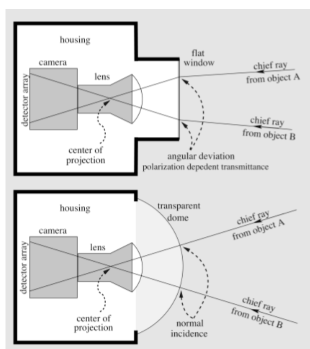
Imaging infrastructure

- Possible solutions (Yoav Y. Schechner, Technion Israel Inst. of Technology)



Composition of multiple images aquired with different polarized angles

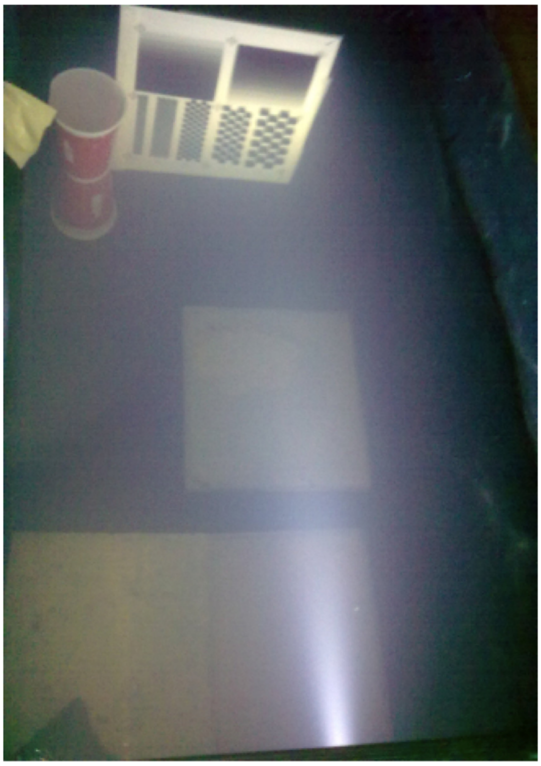


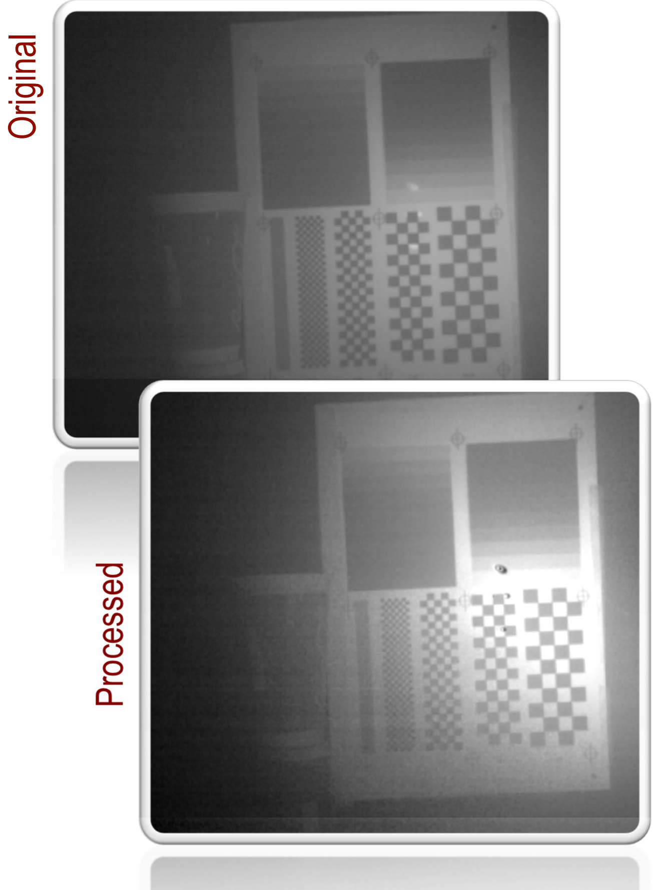


Camera + Lens + Lighting geometric configuration

Imaging infrastructure

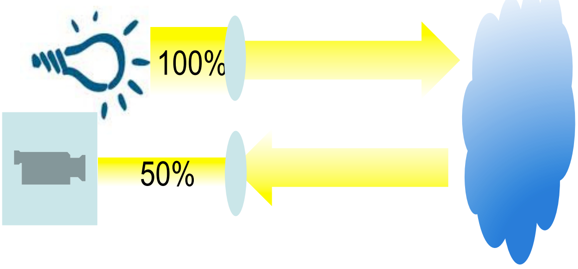
- Experimental setup

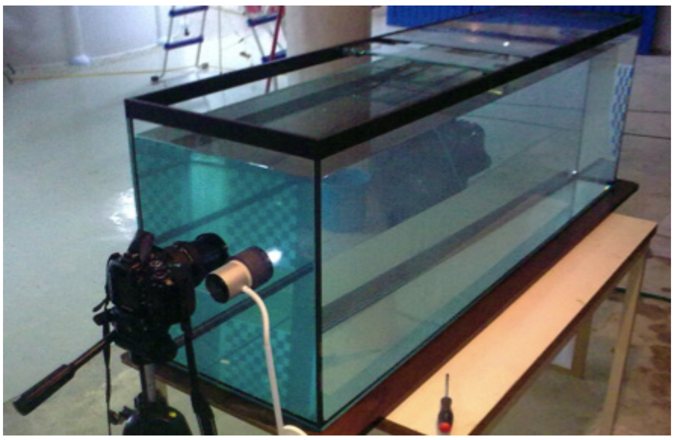




Imaging infrastructure

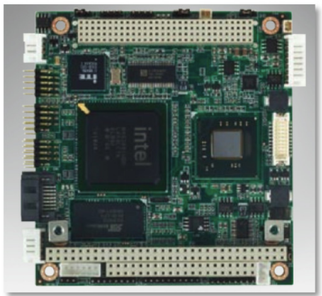
- Drawbacks
  - Energy wasted (double filtering)
  - Not necessary in many scenarios (clear water
  - Computing time consuming
  - Marine snow can be reduced by adequate focus placement
  - Ultra-white (>6400ºK) LED based systems increase light penetration and operational area
  - Requires accurate calibration and stable conditions
- Conclusion
  - Not adequate for this Project





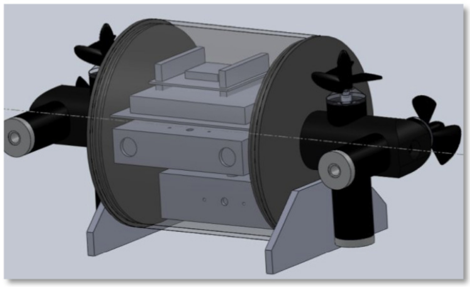
Imaging infrastructure

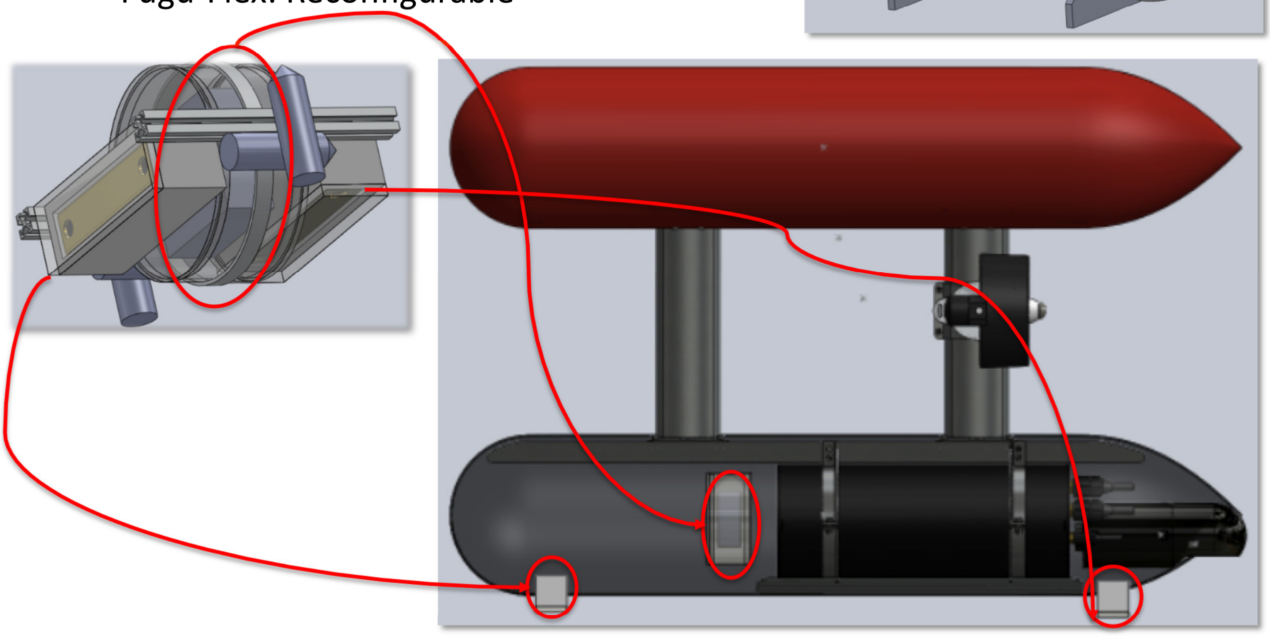
- FUGU a flexible vision module
  - Watertight case and waterproof connectors (21cm ⃠ x 23cm W)
  - 4 Thrusters
  - Controller board, Spotlight, Batteries
  - Two bumblebee2 stereo systems
    - Robust enclosure factory calibrated stereo system
    - 3.8mm focal length (66º HFOV)
    - Image resolution 1024x768 pixels
    - Frame rate 20 FPS
    - <1cm depth accuracy for 1-2m scene depth
    - Firewire interface
  - PCM-3362
    - Chipset Intel Atom N450 @ 1.66 GHz
    - 2 GB SDRAM
    - PC/104 + form factor
  - Nano IMU, pressure sensor, flood detector
  - Firewire extension board, Wi-fi, Ethernet switch
- Structure delivered in October 2010



Imaging infrastructure

- **FUGU**: Auxiliary mini vehicle to speed up the vision system development
  - Hardware replica of the I-AUV vision system
  - Fugu-Compact: Robust
  - Fugu-Flex: Reconfigurable

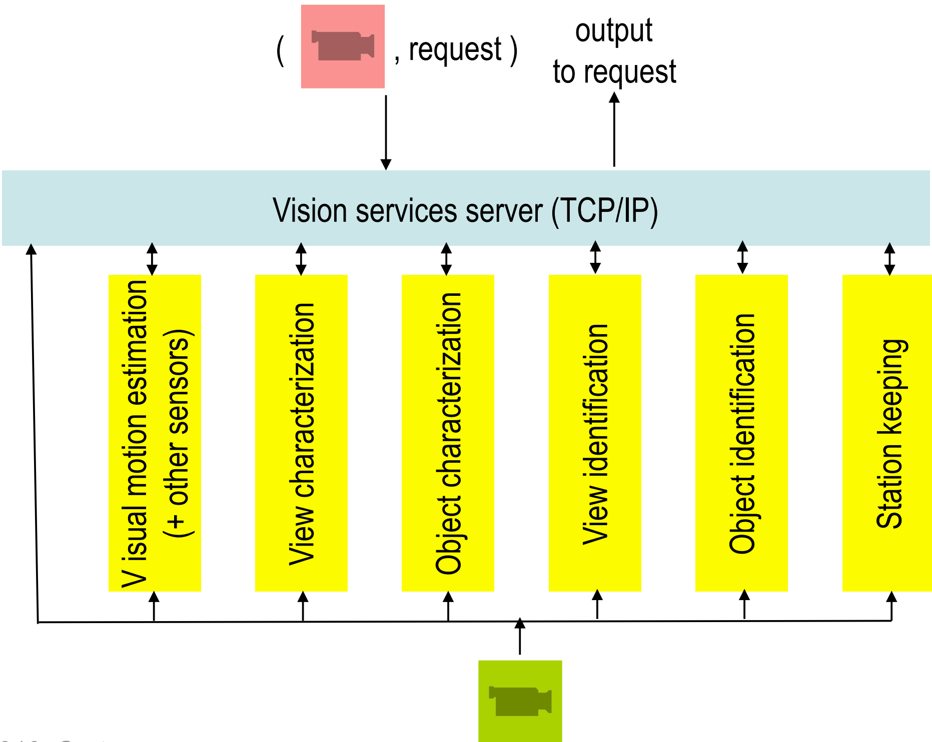




Imaging infrastructure

Imaging infrastructure

- **Vision as a collection of services that can be requested via a TCP/IP protocol:**



Imaging infrastructure

- Image processing modules under development
  - Visual motion estimation (odometer)
  - Object characterization
  - Object identification
  - Station keeping
  - View characterization
  - View identification

Feature detection, description and matching

Main edges orientation histogram

Topological map representation of the surveyed area: Views characterized by its saliency index are the nodes of the map

Visual Odometer

- Odometry as a testbed

Stable features detection → Feature description → Feature matching → Motion estimation

Robust, Rot. & Sc. invariant, RT operation
- FAST
- SURF
- CenSurE

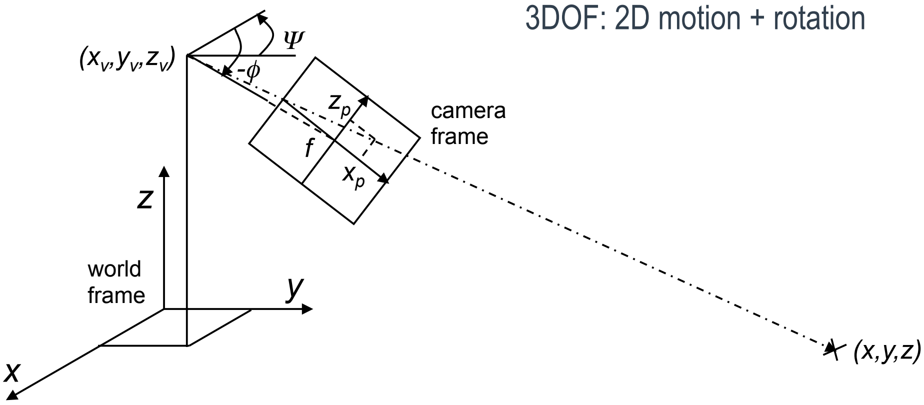
Particle Filter Methodology
Homography Estimation

Visual Odometer

- Preliminary approach:
  - flat seabed
  - vehicle height (z_v) is known
  - camera pitch angle (Φ) is known
  - calibrated camera

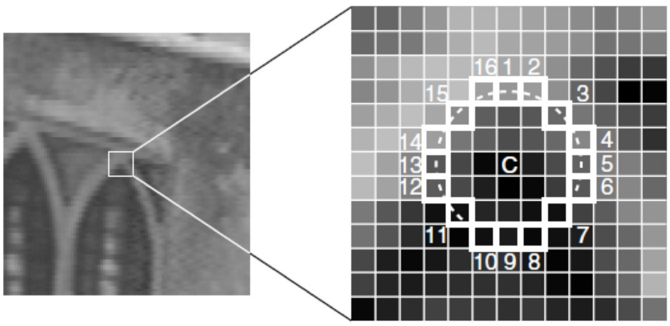
closed form solution that determines (Δx_v , Δy_v , $\Delta\Psi$) within a least-squares framework

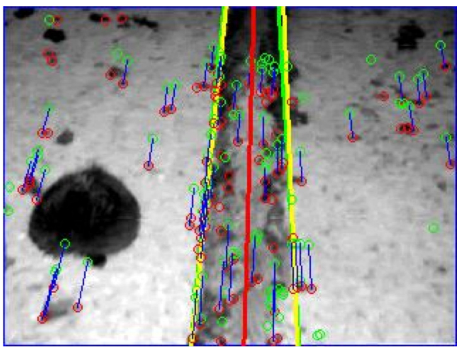
3DOF: 2D motion + rotation



Visual Odometer

- Two variants:
  - generic odometer → constrained problem
  - small yaw rotation → unconstrained problem
- FAST & SURF features

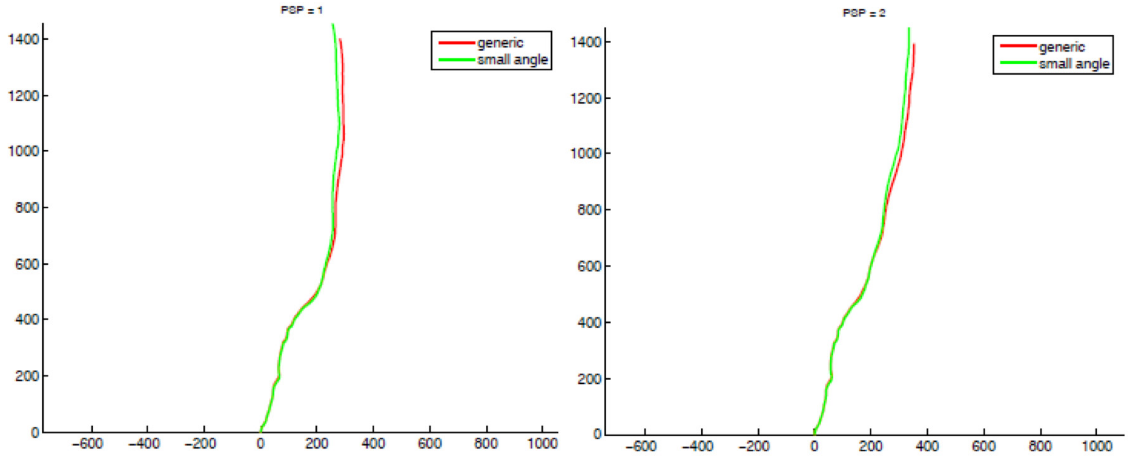




- feature detection + matching + motion estimation:
  - > 10 Hz – Intel Celeron 600 MHz, 320 x 240 pixel monochrome images

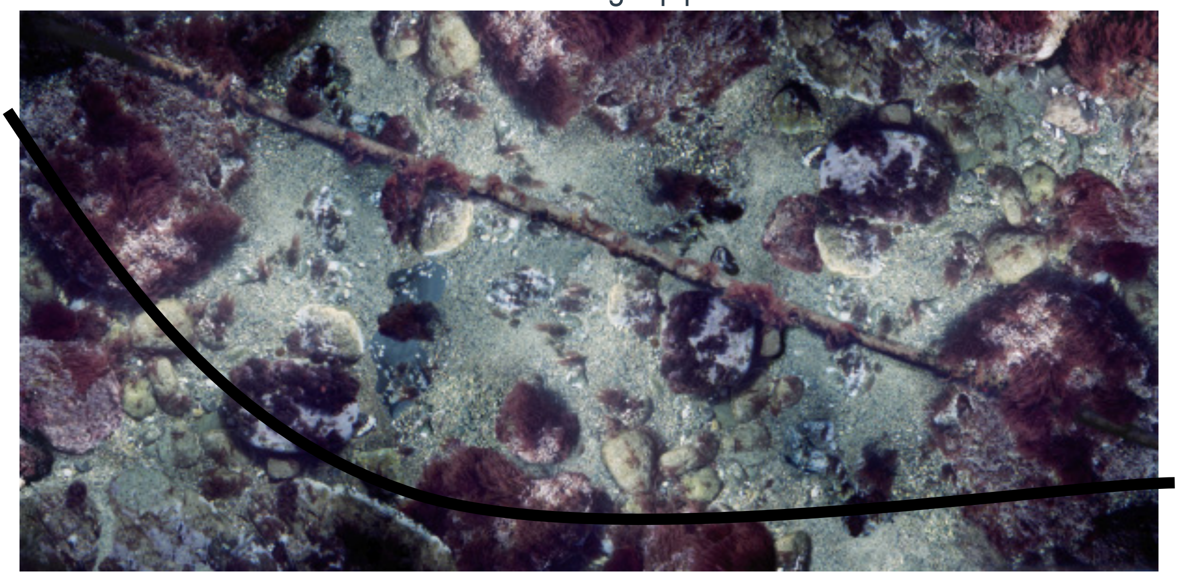
Visual Odometer

- **Off-line experiments**
  - pre-recorded image sequences
  - no information available about camera



Visual Odometer

- **On-line experiments** (under laboratory conditions, camera calibrated):
  - canvas with a seabed mosaic containing a pipe and a telecomm cable



Vision System for an I-AUV

- Present and Future work
  - Assess odometers performance against ground truth in larger environments
  - Check different features performance (SIFT, SURF, FAST)
  - 6DOF positioning with stereo vision information
  - Fusion odometer with sonar-based positioning algorithms
  - 3D Mosaicking