A new compact, cost-efficient concept for underwater range-gated imaging

Jens T. Thielemann, Karl H. Haugholt¹, Odd Løvhaugen, Henrik Schumann-Olsen
SINTEF ICT, Oslo, NORWAY

¹Senior researcher, Project Technical Manager

Karl.H.Haugholt@sintef.no

http://utofia.eu/

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Outline

• UTOFIA project and it's purpose
• Imaging principle
  – and a disclaimer
• Preliminary results
• The coming milestones
First Results

Quay side images (Oslo harbour) at 7,5 meter object-to-camera distance. **Backscatter is a major problem** when camera and light source is in the same housing!

3 regions: Image enhancement possible, Noise from backscatter dominates, Saturation
The UTOFIA project

- Developing a **compact**, cost-efficient, robust range gated camera
- Increase imaging range by 2-3 times the standard camera
- Video-rate images and 3D
- Significant impact on
  - Underwater imaging
  - Subsea applications

Range gating: Fills the sensor gap
Use cases for validation

• Benthic habitat and population mapping:
  - compared with traditional sensors surveys for the assessment of Nephrops (North Sea)

• Marine litter survey
  - and performance assessed compared to existing technologies in variable visibility conditions (Marseille harbour)

• Pelagic fish school size and species identification
  - explore the feasibility of 3D imaging for pre-screening fish schools for fisheries applications (Bay of Biscay)

Photo credit: Gilbert van Ryckevorsel (NOAA)
Partners and project

- All partners are world leaders in their fields
  - Laser and sensor technology
  - Subsea and marine technology
- Technical and project leadership: SINTEF
- Project financed by European Commission
  - Top 5% of all project proposals in call
  - 5.7 M€ total budget (grant 633098).
  - Blue Growth, Horizon 2020
  - Started Feb. 1st 2015
Advisory Board

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• **Dr. Vincent Rigaud** (Head of Underwater Systems Dept.)
  IFREMER (French Marine Research Institute)
"Disclaimer"

- It is limited how much technical detail that can be disclosed at the present time - for two reasons:
  - There are some IPR issues that need to be settled
  - We do not know how the final solution will end up like
Range gating: Principle of operation

- Scattered light takes a "short cut" and arrives before light from the target
- Removes early arriving (scattered) light occurring from the water volume
- This also provides range ability and 3D ability
Preliminary results

• Prototype Zero – Built with off-the-shelf components that we have modified
  – Housing and test object built in two weeks
  – Sensor is not calibrated for off-set and gain yet

• Result I – Back scatter reduction
  – Comparison with GoPro camera with green LED source

• Result II – 3D ability
Prototype Zero – Off-the-shelf components

Housing and test object

GoPro Camera and LED source

Range gated Prototype
40ltr outside
But only 6ltr “active”
Volume inside
Result I – Back scatter reduction

GoPro Camera

UTOFIA prototype

Approximately 7.5m
Image enhancement

• Large effort on image algorithms development

• 1000 range gated images per second!

• Processed images at video rate

• Contrast increase by removing backscattered light

• Contrast increase by alternating between images with a smaller range difference

• Longer range – better manoeuvrability, safer operation
Result II – 3D ability

Gating: ~7.75 m

Gating: 7.25 m

Gating: ~6.75 m

Gating: ~6.25 m
Much worse water in this test, More than 1000x attenuation at 5.5m: Still 3D

Target.
Offset 10, 30, 60 cm

GoPro image.
Distance to target 5.5 meters

UTOFIA image.
Top most object "easily" discerned
A 3D image gives correct dimensions

- Knowing the distance to an object gives the transverse dimensions in an image, that is the size of the fish.
- Knowing the 3D form of an object improves identification of object
- Slicing the scene in depth gives new methods to segment out individual objects in the image
The coming milestones

**Timeline:**
- Feb 2015: Project started
- Sep 2015: Design complete
- Nov 2016: First prototype (10 Ltr volume)
- Nov 2017: Final prototype ready for commercialisation

**Predicted price regime (20-40 k€ per unit)**
- **Volume:** 5 - 10 litres
- **Weight:** 5 - 10 kg
- Depends on feedback from end users

**For the next Blue Photonics conference we hope to show you all the technical details of UTOFIA**
More 3D "delay sweep"

Raw data from last week. Unfortunately image is out of focus. We have started an effort of fixed pattern noise removal and sensor calibration. Test images shows significantly improvement. But even with stripes and FPN we hope this gives a flavour of what this concept can achieve!