Seapix : A Multi-Usage Multibeam Sonar for Hydrography and Robotics Applications

David Vincentelli
Didier Charlot
<table>
<thead>
<tr>
<th></th>
<th>Table of contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sonar Imaging at iXblue</td>
</tr>
<tr>
<td>2.</td>
<td>Seapix</td>
</tr>
<tr>
<td>3.</td>
<td>Biomass Analysis</td>
</tr>
<tr>
<td>4.</td>
<td>Obstacle Avoidance</td>
</tr>
<tr>
<td>5.</td>
<td>Station Based Imaging</td>
</tr>
<tr>
<td>6.</td>
<td>Backscatter Imaging</td>
</tr>
<tr>
<td>7.</td>
<td>Navigation</td>
</tr>
<tr>
<td>8.</td>
<td>Sound Velocity Profile Estimation</td>
</tr>
<tr>
<td>9.</td>
<td>Perspectives</td>
</tr>
</tbody>
</table>
1

Sonar Imaging at iXblue
Sonar Imaging at iXblue: from near surface to subbottom

A multi-usage multibeam sonar for hydrography and robotics applications
Seapix
Multibeam/Multiswath Echosounder
Seapix
Project Specifications, Development

SEAPIX Research&Development
• start in 2007, First prototype 2010
• 2 FUI (Optipêche/Tactipêche)
• 1 RAPID

Context&Market
• Fisheries
• Security/Economic
• Selectivity and Sustainable Policy
• Fisheries resources evaluation in collaboration with scientific (vessel of opportunity)

Requirement Specifications
• Volumetric scanning of the water column
• Bathymetry up to 400m
• Target detection -35dB up to 200m
• Limited size (Φ< 50cm)
• Bathymetry IHO Standard

Challenges
• Tradeoff hardware cost/level of performances
• from single beam to multibeam interpretation
Seapix

Market

Fisheries, Pelagic: 40 systems since 2014

A multi-usage multibeam sonar for hydrography and robotics applications
## Seapix System Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>480mmx180mm</td>
</tr>
<tr>
<td>Weight</td>
<td>60/40 kg</td>
</tr>
<tr>
<td>Power consumption</td>
<td>200W (500W Peak)</td>
</tr>
<tr>
<td>Number of transducers</td>
<td>2x 64 Rx and Tx</td>
</tr>
<tr>
<td>Sensor immersion</td>
<td>20m</td>
</tr>
<tr>
<td>Beam Stabilization</td>
<td>On Tx and Rx</td>
</tr>
<tr>
<td>Frequency</td>
<td>150khz</td>
</tr>
<tr>
<td>Bandwith</td>
<td>10khz (7.5cm res.)</td>
</tr>
<tr>
<td>Modulation</td>
<td>CW or FM</td>
</tr>
<tr>
<td>Beam number</td>
<td>64 beams</td>
</tr>
<tr>
<td>Transmit Power</td>
<td>1kW</td>
</tr>
<tr>
<td>Beam Steering</td>
<td>+/-60° for/aft port/starboard</td>
</tr>
<tr>
<td>Transmit Swath width</td>
<td>120 °x 1.6°</td>
</tr>
</tbody>
</table>
Seapix
Sonar Head

A multi-usage multibeam sonar for hydrography and robotics applications
Seapix
Software

Key features

• 2D/3D Bathy
• 2D/3D Backscatter
• 2D/3D Echograms
• Multiple Echogram
• TS/SV Analysis
• HAC format (EchoView, Movies3D)
Seapix Performances

Bathymetry, ENSTA (2015):
- IHO special order with OCTANS

BaraPemdez, June 2014, scale SV [-60dB,-18dB], central beam

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Seapix
Multiple Swath Imaging

Versatile Configuration

- User defined insonification scenario
- CW/FM
- Switch Rx/Tx antenna
- Steering angle interval and increment
Seapix

Downward Looking Configuration

Volume 120° x 120°
7cm radial resolution
1.6° x 1.6° up to 1.6° x 3.2° angle resolution
Seapix
Forward Looking Configuration

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Biomass Analysis
Biomass Analysis
Multiple Echograms Visualization

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Biomass Analysis
Detection with 2D/3D Mapping and Bathymetry
Biomass Analysis
Geographical Biomass Analyzer

Main Acoustic Response
Nb of individuals
TS or SV

Class Name

Min level Filter
Max level Filter
Water Layer depth

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Obstacle Avoidance
Obstacle Avoidance
Forward Looking Bathymetry
Obstacle Avoidance
Detection in the Water Column

A multi-usage multibeam sonar for hydrography and robotics applications
Station Based Imaging
Station Based Imaging

Bathymetry

Seapix is fixed on a barge
Bathymetry area ~ 1200m² at 10m depth
Station Based Imaging
Biomass Analysis
6 Backscatter Imaging
Backscatter Imaging
Conventional Imagery Mode

A multi-usage multibeam sonar for hydrography and robotics applications
Backscatter Imaging
Conventional Imagery Mode with Seapix
Backscatter Imaging
Multiple Imaging Modes

Horizontal Forward Looking

Conventional Bathymetry & Imagery

Longitudinal
Backscatter Imaging

Forward Looking Imaging

Vertical Imaging:
- Specular reflection
- Bad contrast at nadir

Forward Looking Imaging:
- Specular reflection suppressed
- Higher shadows contrast

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Backscatter Imaging

Longitudinal Imaging Mode:

→ Full BS profil vs Incidence Angle
Backscatter Imaging
Seabed Classification: data

Bathymetry Mode

Longitudinal Mode

Level Based Classifier
Input data:
\( \{\theta_x, BS_x\} \) for pixel \( x \)

Profile Based Classifier
Input data:
profile \( BS_x(\theta) \) for pixel \( x \)

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Backscatter Imaging
Seabed Classifier

• Level-based classifier
  • Input data: \( \{\theta_x, BS_x\} \) for pixel \( x \)
  • For each class, estimating gaussian model of BS level for each angular sector \( \theta \): \( P_{\theta}(BS) \)
  • \( C_x = \arg\max_C P_{\theta_x}(BS_x|C) \)

• Profile-based classifier
  • Input data: profile \( BS_x(\theta) \) for pixel \( x \)
  • Estimating multi-dimensionnal Gaussian model \( P(BS(\theta)) = \text{Gaussian}(BS(\theta)|\mu(\theta), \Sigma(\theta)) \)
  • \( C_x = \arg\max_C P(BS_x(\theta)|C) \)
Backscatter Imaging
Seafloor Classification: Results

Mode Transversal

<table>
<thead>
<tr>
<th></th>
<th>P.D</th>
<th>P.E</th>
<th>S.</th>
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<tbody>
<tr>
<td>P.D.</td>
<td>87</td>
<td>13</td>
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<tr>
<td>P.E</td>
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<tr>
<td>S.</td>
<td>1</td>
<td>2</td>
<td>97</td>
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Mode Longitudinal

<table>
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<th>S.</th>
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</thead>
<tbody>
<tr>
<td>P.D.</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>P.E</td>
<td>3</td>
<td>97</td>
<td>0</td>
</tr>
<tr>
<td>S.</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
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Navigation
Navigation
Doppler Velocity Log

Multibeam Doppler Velocity Log

• Alternate Longitudinal/Transversal Mode
• 64x64 Beams, 1.6°x1.6°
Sound Velocity Profile Estimation
Sound Velocity Profile Estimation

Principle

Using overlapped Bathymetry Profiles on successive pings, longitudinal/transversal

Sound Velocity Model

\[ C(z, \theta) \]

\[ \Theta : \text{paramètres} \]

\[ \hat{\theta} = \arg\min_{\theta} \sum_{x, i, j} [z(i, x) - z(j, x)]^2 \]
Perspectives
Perspectives
MultiBeam/MultiSwath System on AUV/ROV/ASV

One system for multiple functions

Navigation Security
  • Forward Looking Detection

Hydrography
  • Sound Velocity Profile Estimation

Imagery
  • GapFiller

Environment Assessment and Monitoring
  • Robust Seafloor classification
  • Biomass analysis

Navigation
  • Navigation + MBES (DVL, Bathymetry)

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