Otolith Shape Feature Extraction
Oriented to Artificial Neural Network Classification

J. Piera ¹, V. Parisi ², S. Bermejo ², J. Cabestany ²
E. Garcia-Ladona ³, A. Lombarte ³

1. Signal Theory and Communications Dep. UPC. Barcelona. Spain
2. Electronic Engineering Dep. UPC. Barcelona. Spain
3. Institut Ciències del Mar. CSIC. Barcelona. Spain

Otolith image (MxN pixels)
contour extraction
shape codification
feature extraction

K pixels
K=MxN

p₁ p₂ p₃ pₖ

input set 1

Otolith image (MxN pixels)

ANN MODEL 1

J descriptors
J <<K

d₁ d₂ d₃ dₖ

input set 2

ANN MODEL 2

Artificial Neural Network Classification.
Model options
Contour extraction and shape codification

Vector \[(x(n), y(n))\]

Complex \[u(n) = x(n) + j y(n)\]

Contour extraction and shape codification

Binarization

Contour extraction

Contour codification

Cartesian

Polar

Coordinate transformation

Polar to Cartesian coordinates

Reconstruction limitations
Future applications
Analysis of data from different resources

Potential differences on

- Otolith position
- Image resolution
- Origin of reference
- Clockwise / Anticlockwise codification

Goal

- Propose a method for standardizing the codification of contours obtained from different resources
- Evaluate the effect of using different types of codification on the feature extraction process
Contour standardization method

KL Transform
512 points

Contour standardization test

1 2 3 ...

1 20
Contour standardization test (II)  
Coordinate error

x-coordinate

n= 9728

90% confidence interval

[-0.0156, 0.0165]

y-coordinate

n= 9728

90% confidence interval

[-0.0127, 0.0136]

Codification effect evaluation

Otolith data set European hake *Merluccius merluccius* (L.)

<table>
<thead>
<tr>
<th>Class</th>
<th>Sex</th>
<th>Maturity stage</th>
<th>length</th>
<th># samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>Undetermined</td>
<td>Juvenile 1st year</td>
<td>&lt; 16 cm</td>
<td>24</td>
</tr>
<tr>
<td>Class II</td>
<td>Male</td>
<td>Juvenile, after 1st year</td>
<td>[16-28.8] cm</td>
<td>18</td>
</tr>
<tr>
<td>Class III</td>
<td>Female</td>
<td>Juvenile, after 1st year</td>
<td>[16-38.0] cm</td>
<td>25</td>
</tr>
<tr>
<td>Class IV</td>
<td>Male</td>
<td>Adult</td>
<td>&gt; 28.8 cm</td>
<td>23</td>
</tr>
<tr>
<td>Class V</td>
<td>Female</td>
<td>Adult</td>
<td>[38.0-60.0] cm</td>
<td>31</td>
</tr>
<tr>
<td>Class VI</td>
<td>Female</td>
<td>Adult</td>
<td>&gt; 60 cm</td>
<td>9</td>
</tr>
</tbody>
</table>
Codification effect evaluation (II)
Feature descriptors

- **Morphological** (11 features)
  - Perimeter, Max chord, Major and Minor Axis, …

- **Statistical** (27 features)
  - Mean, Variance, Fractal dimension, …

- **Spectral** (256 features)
  - Normalized Fourier descriptors

- **Multiscale** (64 features)
  - Normalized Multiscale Bending energy

Fractal dimension
Box-counting method
Bending Energy

\[ k(t) = \frac{\ddot{x}(t)\dddot{y}(t) - \dddot{x}(t)\ddot{y}(t)}{\left(\dddot{x}(t)^2 + \ddot{y}(t)^2\right)^{3/2}} \]

\[ B = \frac{1}{N} \sum_{n=0}^{N-1} k[n]^2 \]

Normalized multiscale bending energy NMBE

\[ \log_{10}(\text{NMBE}) \]

\[ \log_{10}(\text{scale}) \]
Class Separation Distance (CSD)

Value distribution for feature $m$

Class Separation Distance (CSD) between the $l$ and $k$ classes with respect to the $m$th feature

$$CSD_{l,k,m} = \frac{|\mu_{l,m} - \mu_{k,m}|}{\sqrt{\sigma^2_{l,m} + \sigma^2_{k,m}}}$$

Mean CSD$_m$
Max CSD$_m$
Min CSD$_m$

Changes on CSD statistics using different codifications

Morphological
Fractal dimension & stats.

Normalized Multiscale Bending Energy
Fourier coefficients

Cartesian coordinates
Polar coordinates
Effect of codification method
Example: NMBE

Cartesian coordinates

Polar coordinates

Cartesian coordinates

Polar coordinates

Effect of codification method: Statistics of NMBE

Cartesian. NMBE mean

Cartesian. NMBE variance

Polar. NMBE mean

Polar. NMBE variance

juv_I
juv_M
juv_F
adt_M
adt_F1
adt_F2
Conclusions

- The KL transform derived method allows standardizing coordinates of otolith shape data.

- The classification may depend on the selected codification method.

- Proposal: Establish a standard data format within Shape Analysis Community Research.

Acknowledgments

Beatriz Morales  Coordinator of IBACS project
Antoni Cruz  (ICM, CSIC) Image acquisition
Albert Marti (EPSC, UPC) Software development