Control and Guidance Systems for the Navigation of a Biomimetic Autonomous Underwater Vehicle

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Applications

• pipeline inspection
• deep sea exploration
• mines clearing operations
• biological studies
State of Art

Traditional

AUVs

Biomimetic

BCF

PMF
Open Issues

Limiting factors:

• Limitation of battery power
  Biomimetic propulsion

• Autonomous operation
  Navigation, guidance and control systems
Contribution

• control system design
• guidance system design
• analysis of ocean current

RoboSalmon AUV

Target position

Guidance Law

reference heading

Vehicle Dynamics

Vehicle position and velocities

tail offset

heading

ocean current

Tail Control
The RoboSalmon

• Morphology:
  - 0.85 m in length
  - 4.88 kg in weights
  - sub-carrangiform swimming mode

• Propulsion System:
  - Single actuated ten joints tail
Mathematical Model

• Dynamics:

\[ M\dot{\mathbf{v}} + C(\mathbf{v})\mathbf{v} + D(\mathbf{v})\mathbf{v} + g(\mathbf{\eta}) = \mathbf{\tau} \]

• Control vector:

\[ \mathbf{\tau} = \mathbf{\tau}(t,\xi) \]

\[ \left\{ \begin{array}{l}
\mathbf{\tau}(t + T,\xi) = \mathbf{\tau}(t,\xi) \\
\int_{t_0}^{t_0 + T} \mathbf{\tau}(t,\xi) dt = \bar{\mathbf{\tau}}(\xi)
\end{array} \right. \]
Heading Control Systems

• PID Algorithm:

• Sliding Mode Control:
Line of Sight Guidance Law:

\[ \psi = \tan^{-1}\left( \frac{y_* - y(t)}{x_* - x(t)} \right) \]

waypoint guidance
Comparison

Powers:
- electrical
- mechanical
Ocean Current Disturbances
Conclusions

• Conclusion:
  ▪ Suitable control and guidance systems
  ▪ Sliding mode guarantees better performances

• Future work:
  ▪ Change the mechanic of the tail propulsion system
  ▪ More advanced control systems
Grazie per l’attenzione