Keynote proposal

to

STC-Dn

“Bio-inspired Designs and Functional Applications”

Presenter: A. Malshe (1)
Role of design, types of designs and interplay of design with other parameters as Nature applies selected designs to deliver multi-functionality.
## Previous and upcoming CIRP contribution to the area

<table>
<thead>
<tr>
<th>Year</th>
<th>Authors</th>
<th>Conceptual Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>Mak T.W. and Shu L.H.</td>
<td>Biological analogies to for problem solving. Bio-inspired solution strategies</td>
</tr>
<tr>
<td>2008</td>
<td>Bruzzone A.A.G. et al.</td>
<td>Surfaces, functional properties of surfaces, applications and manufacturing</td>
</tr>
<tr>
<td>2020</td>
<td>Brinksmeier et al.</td>
<td>Manufacturing of multiscale structured surfaces (STS-S: 2020)</td>
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Framework of proposed keynote paper manuscript
Bio-inspired Designs and Functional Applications

The objective is to discuss DESIGNS for enhancing product functionality, production efficiency, energy conversation, materials sustainability inspired from STRATEGIES adopted in Nature.
Driver questions for proposed Keynote

• Natural selection of designs

• Preferred designs: Designers’ Tool Box

• Analysis of preferred design architectures

• Manufacturing processes and to produce these designs

• Applications using these designs
Bio-inspired Design Architectures for Advanced Products

Outline of the keynote paper: (Technical scope)

1. Introduction: Robust designs in Nature
2. Common design approaches in Nature (with examples) and understanding the design strategies in Nature
3. Design tools and modeling
4. Selection of manufacturing processes and applications
5. Summary and Future Directions

INTENDED TIMELINE : 2021-2022
Highlights

• Expected number of authors: 4(-5)
• Minimum three authors from CIRP
• Minimum one author from STC-Dn
• Potential one other author from non-CIRP community
List of CIRP Keynotes published by Prof. Malshe

- “Bio-inspired textures for functional applications” Malshe et al. (2018 Cross-STC keynote)

- “Bio-inspired Functional Surfaces for Advanced Applications” Malshe et al. (2013 STC-S keynote)

- “Tip-based nanomanufacturing by electrical, chemical, mechanical and thermal processes” Malshe et al. (2010 STC-E keynote)

- “Micro additive manufacturing using ultra short laser pulses” BH in't Veld et al. (2015 STC-E keynote)

- “Biomedical production of implants by additive electro-chemical and physical processes” Bartolo et al. (2012 STC-E keynote)

- “Laser nano-manufacturing - State of the art and challenges” Li et al. (2011 STC-E keynote)
List of other CIRP publications published by Prof. Malshe

• 2017 (STC-S) - “Understanding evolution of tribo-chemical interfaces during boundary lubrication in manufacturing”

• 2016 (STC-E) - “Investigation of hydrodynamic arc breaking mechanism in Blasting Erosion Arc Machining”

• 2014 (STC-E) - “Ultrasonic Machining of Biomass using Biodegradable Slurry”

• 2012 (STC-G) - “Study of Tribo-Chemical Lubricant Film Formation During Application of Nanolubricants in Minimum Quantity Lubrication (MQL) Grinding”

• 2011 (STC-E) - “Experimental Characterization of Dry EDM performed in a Pulsating Magnetic Field”

• 2008 (STC-E) - “Understanding Behavior of Machining Interface and Dielectric Molecular Medium in Nanoscale Electro-Machining”

• 2007 (STC-E) - “Understanding Dielectric Breakdown and Related Tool Wear Characteristics in Nanoscale Electro-Machining Process”

• 2005 (STC-E) - “Investigation of Nanoscale Electro Machining (nano-EM) in Dielectric Oil”

• 2005 (STC-E) - “Investigation of Femtosecond Laser-assisted Micromachining of Lithium Niobate”
Detailed scope of individual sections of the manuscript
Section 1: Why Bio-inspired designs??

- How robust designs in Nature have evolved over time in various multi-functional systems

- How manufacturing processes and product designs will be benefited learning from vast library of designs in Nature?

- Acknowledge previous CIRP and other contributions in this area
Section 2: Examples

Discussion of the design features and design architectures in Nature

2.1 Design building blocks
- Spheres and circular shapes
- Hexagons
- more…

2.2 Design arrangements
- Use of branching across length scales
- Layered structures such as Nacre or Helicoids
- more…

2.3 2D and 3D Design forms and their analysis – Overall shape of bio-species (bulk and surfaces)
- e.g. aerodynamic form of bird beaks
Section 2: Examples

2.1 Design building blocks: 
(Across length scales)

Honeycomb  
Snow flakes  
Foam

https://teknocraticrev.wordpress.com/editorials/author-isaias/hexagon-natures-favorite-shape/
https://mathmunch.org/2013/06/18/natural-geometry-hex-and-sacred-geometry/
http://latex-cookbook.net/cookbook/examples/benzene-ring/
https://teknocraticrev.wordpress.com/editorials/author-isaias/hexagon-natures-favorite-shape/
https://teknocraticrev.wordpress.com/editorials/author-isaias/hexagon-natures-favorite-shape/
Section 2: Examples

2.2 Design architectures: Branching
(Across length scales)
Section 3: Design tools and modeling

Scientific rationale behind the commonly observed design attributes in Nature

3.1 What are the driving forces that lead to:
   - Spheres and circular shapes
   - Hexagons

3.2 How the arrangement of features is optimized:
   - Use of branching across length scales
   - Layered structures such as Nacre or Helicoids

3.3 How certain ‘forms’ are optimized for specific function?
   - e.g. aerodynamic form of bird beaks
Section 4: Manufacturing design strategies

Manufacturing processes for producing design strategies on various materials

3.1 2D manufacturing processes

3.2 3D manufacturing processes

3.3 Metrology techniques for design analysis
Section 5: Utilization of the design strategies

Which engineering products are benefited from the knowledge of biological designs

4.1 Aerodynamic designs of trains/planes etc.
4.2 Lightweight composite structures
4.3 Hard and tough structures
4.4 Surfaces for friction management
4.5 Optical and electronic applications
4.6 Transportation systems
4.7 more…

WHERE and HOW these designs can be applied??
Section 6: Conclusions and future directions