PhD Proposal 2017

School:	
Laboratory: IRCCyN	**Web site: http://www.irccyn.ec-nantes.fr/en/**
Team: Robotics	**Head of the team: Philippe Wenger**
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Collaboration with other partner during this PhD: **In France: MNHN**	**In China:**

Title: Kinetostatic analysis and design of tensegrity mechanisms, application to the modeling of musculoskeletal systems
Scientific field: robotics
Key words: robotics, tensegrity, mechanism, musculoskeletal system, bioinspired design

Details for the subject:

(Maximal length of 2 pages, including images, list of reference, …The pdf file should not exceed 1Mo)

Background, Context:

In the context of bio-inspired design of innovative robots with better performances, bird necks have been shown by biologists to have interesting features that would provide very efficient designs for roboticists. This work will take place in the frame of a collaboration between IRCCyN and the MNHM (Museum National d'Histoire Naturelle).

Research subject, work plan:

Existing robots have limited performances as compared to living organisms. One of the main reasons comes from their inherent mechanical structures. It has been shown recently that most biological systems can be modeled using the concept of tensegrity ("tensile-integrity"). Tensegrity structures are made of isolated elements subject to tension and compression. The compressed members (bars or struts) lie inside a net of continuous tension made of pre-stressed tension elements (cables or tendons). Originally, tensegrity structures were introduced by architects and artists to build elevated constructions [1], see fig. 1.

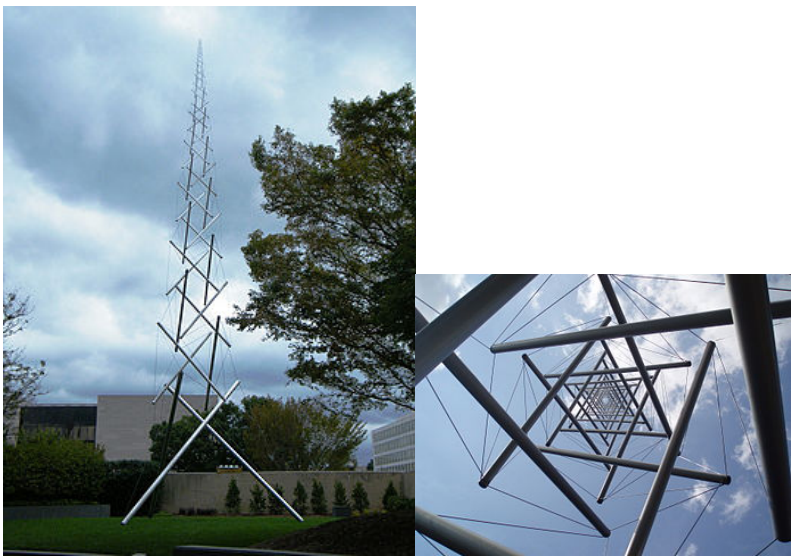

Fig. 1 The Needle Tower by Kenneth Snelson

More recently, tensegrity structures have been used to model various biological systems such as cells and human spines [2-4], see fig. 2. We then speak of biotensegrity.

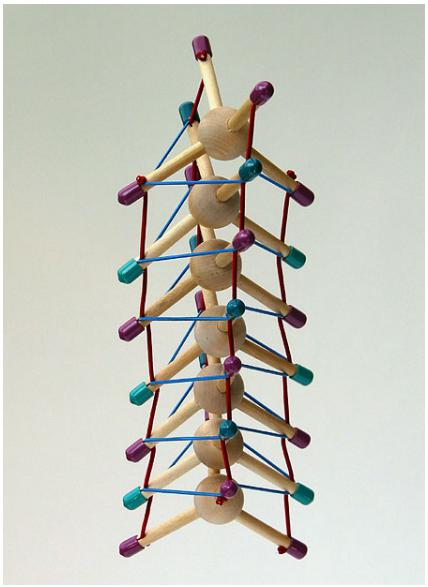

Fig. 2 Tensegrity structure as a model of human spine

Some roboticists have also tried to use tensegrity structures as alternative robot designs [5, 6]. Tensegrity structures possess a number of interesting features such as lightness and the ability to store energy. Literature review reveals few links between the two research communities (biology and mechanics). The goal of the proposed master thesis is to understand the role of tensegrity in living organisms and how this concept could be applied to the design of high-performance robots.
This thesis will take part of a cooperative research work between IRCCyN and biologists at the Museum National d'Histoire Naturelle. A special focus will be brought to the understanding and modeling of bird necks, which turn out to have very interesting performance.

Proposed work plan:

- Detailed analysis of the existing literature on tensegrity mechanisms
- Analysis of simple application examples
- Proposition of adequate planar models of bird necks
- Study of 3D models
- Prototype building and experiments

References:

[1] Fuller RB. Tensile-integrity structures. US patent 3,063,521. November 13, 1962.
[2] Randel L. Swanson II, Biotensegrity: A Unifying Theory of Biological Architecture With Applications to Osteopathic Practice, Education, and Research—A Review and Analysis. The Journal of the American Osteopathic Association January 2013 | Vol 113 | No. 1.
[3] Levin SM. The tensegrity-truss as a model for spine mechanics: biotensegrity. JMMB. 2002;2(3):375-388.
[4] Andrew P Sabelhaus, Hao Ji, Patrick Hylton, Yakshu Madaan, ChanWoo Yang, Alice M Agogino, Je_rey Friesen, and Vytas SunSpiral. Mechanism design and simulation of the ultra spine, a tensegrity robot. In Proceedings of the ASME 2015 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference,
Boston, MA, USA, 2015.
[5] Arsenault, M., and Gosselin, C., 2006, "Kinematic, Static and Dynamic Analysis of a Planar 2-DoF Tensegrity Mechanism," Mech. Mach. Theory, 41(9), pp. 1072–1089.
[6] Nouri Rahmat Abadi, B., Farid, M., and Mahzoon, M., 2014, "Introducing and Analyzing a Novel Three-Degree-of-Freedom Spatial Tensegrity Mechanism," J. Comput. Nonlinear Dyn., 9(2), p. 021017.