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BIOMIMETIC DEVELOPMENT OF TECHNOLOGY TO ASSIST, ENHANCE AND EXPAND HUMAN SENSORY PERCEPTIONS – ON THE IMPORTANCE OF COLLABORATION WITH THE FUNDAMENTAL SCIENCES

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THE HUMAN BODY is equipped with various senses; we can, e.g., smell, hear, taste, feel touch, see and sense temperature. Our senses are of extraordinary value but we cannot change them even if this proves to be a disadvantage in our modern times. However, we can assist, enhance and expand these senses via microelectromechanical systems (MEMS). Current MEMS cover the range of the human sensory system, and additionally provide data about signals that are too weak for the human sensory system (in terms of signal strength) and signal types that are not covered by the human sensory system (Fig. 1).

Werner Nachtigall, one of the great old men of biomimetics in Germany (where it is called Bionik) published in 2009 his meanwhile classic book on learning from living nature for functional design (Nachtigall 2009). In there, he gives 10 principles of biomimetics that can be used and applied by engineers and designers doing biomimetics, even if they do not have any interest in or time for in-depth biological studies. These 10 principles are

- Integration instead of additive construction,
- Optimization of the whole instead of maximization of a single component feature,
- Multi-functionality instead of mono-functionality,
- Fine-tuning regarding the environment,
- Energy efficiency,
- Direct and indirect usage of solar energy,
- Limitation in time instead of unnecessary durability,
- Full recycling instead of piling waste,
- Interconnectedness as opposed to linearity,
- Development via trial-and-error processes.

Various students on the undergraduate and graduate level, from Europe and Asia, have been working in our Arus Perdana Project “Development of a New Generation of MEMS in Medicine” since 2009. They have analyzed senses in organisms (some of which are similar to human senses, but with different bandwidth, e.g. the hearing range of bats that reaches well into the ultrasound, some of which have no equivalent in humans, such as the echolocation abilities of dolphins or the temperature sensing of snakes, which gives them a thermal picture of their prey, in 250 times 250 pixels) and developed ideas how to utilize such senses for applications with people, to assist, enhance and expand their sensory capabilities (Gebeshuber and Majlis 2010, Karman et al 2011, Makarczuk et al 2011).

Various scientific publications and conference presentations resulted from this research. Now we have started to work on the development of real-world prototypes. And here – as in various other stages of the research – Nachtigall's biomimetic principles are utilized to channel the output towards sustainable, usable, innovative, applicable products. In our interdisciplinary approach existing MEMS sensor designs are modified and adapted (to keep costs at bay), via biomimetic knowledge transfer (Gebeshuber 2011, Gruber et al 2011) of outstanding sensory perception in 'best practice' organisms (e.g. thermoreception, UV sensing, electromagnetic sense). The MEMS are then linked to the human body (mainly *ex corpore* to avoid ethics conflicts), to assist, enhance and expand human sensory perception (artificial eyes, magnetic sense for facilitated orientation, etc.).

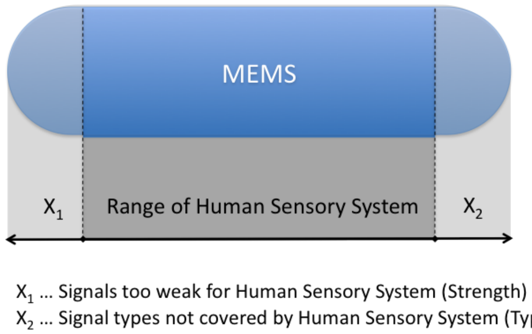

Fig.1 Functional regions of smart MEMS sensors compared to the human sensory system. MEMS cover the range of the human sensory system, and additionally, signals that are too weak for humans to detect (X_1) as well as signal types that we do not at all detect with our normal senses (X_2). (Gebeshuber and Majlis 2010)

Examples of created products in various stages of development comprise sensors that vibrate when a blind person approaches a kerb stone edge, devices that allow divers better orientation under water (echolocation, ultrasound), special glasses that allow vision in the ultraviolet range, vibrating devices on the steering wheel that inform car drivers of low fuel level, enhanced hearing capabilities (ultrasound, infrasound) and electromagnetic senses. The combination of Malaysia's high biomimetic inspiration potential and prototyping facilities can create a significant added value for commercial customers.

But we also encounter problems - the three gaps as identified in Fig. 2 (Gebeshuber, Gruber and Drack 2009) hindering successful merging of science/academia, industry and society are not unknown to us! We are looking forward to related discussions with representatives from science, industry and society at the 4th Fundamental Science Congress 2012 and to identify potential collaborations with the fundamental scientists from physics, mathematics, chemistry, biology and representatives of the industrial sectors who will be present at the congress.

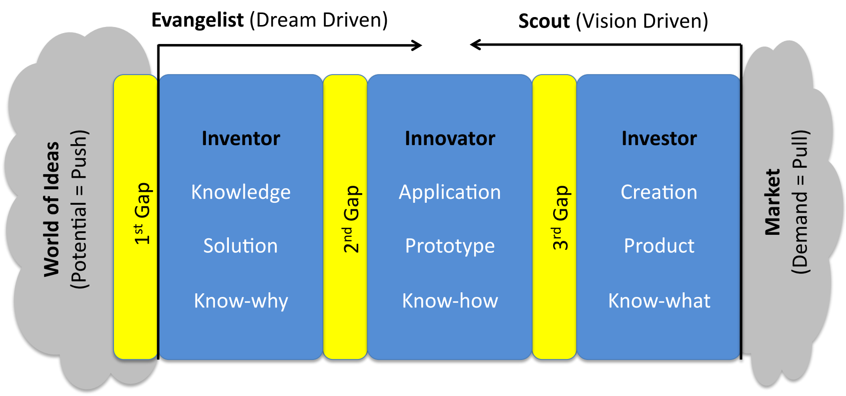

Fig. 2 The three gaps theory hindering successful merging of fundamental science/academia, industry and society. (Gebeshuber, Gruber and Drack 2009)

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