# On the way to the bionic man:
# A novel approach to MEMS based on biological sensory systems

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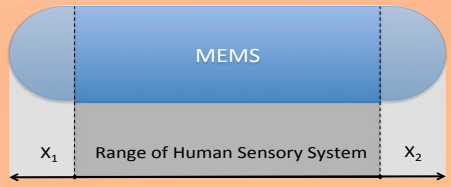
## Abstract

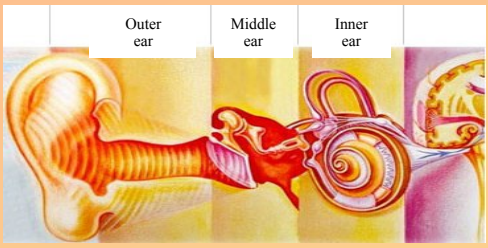
The human senses are of extraordinary value, but we cannot change them, even if this proves to be a disadvantage in our modern times. However, we can assist, enhance and expand these senses via MEMS through push-pull analysis method. The method use the data that carried out based on a concise summary of senses in organisms and MEMS sensors that already have reached the market. The data gives an overview where current MEMS technology excels (available solutions) and where natural sensor systems excel, and provides a knowledge base for further development of MEMS sensors.




$X_1$ ... Signals too weak for Human Sensory System (Strength)
$X_2$ ... Signal types not covered by Human Sensory System (Type)

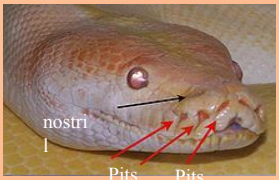
*Functional regions of smart MEMS sensors compared to the human sensory system.*

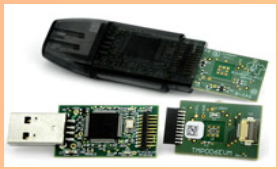
| Senses | Available MEMS sensors |
|---|---|
| Sight | 3D Motion MEMS Sensor, Beast X-3 MEMS Gyro System, MEMS ASIC Photo Chip... |
| Infrared Sensing (Temperature) | 3D MEMS IR Antenna, MEMS Microbolometer, MEMS IR Sensor |
| Hearing | MEMS Microphone, Voice Interface, MEMS Oscillator... |
| Olfaction (Smells) | MEMS Gas Sensor, MEMS Electronic Nose... |
| Vibration Sensing | MEMS Pressure Sensor, MEMS Shock Sensor, MEMS 3-Axis Digital Output Acceleration Sensor |
| Magnetic Sense | MEMS Magnetometer, MEMS Geomagnetic Sensor, MEMS Magnetic Sensors... |
| Electroreception | MEMS Electroreceptor, MEMS Neural Control, MEMS Electrolocator... |

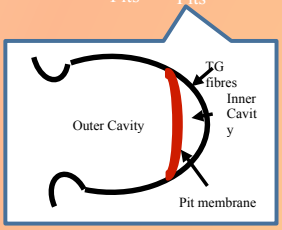


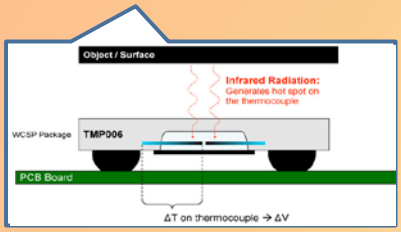

*Human Ear*


*Hearing MEMS Device for Audio System*






*Infrared Sensing (pits organ) in the Python*

*MEMS IR Sensor (TMP 006; Texas Instruments)*

| Senses | Human ability range | Animal sensory system | |
|---|---|---|---|
| | | Animals type | Ability range |
| Sight | Visible light (390 - 750 nm) | mantis shrimp | UV, visible light (300 – 700 nm) |
| | | butterflies, birds, fish | UV, visible light |
| Hearing | 20 to 20000 Hertz | mice | Ultrasound up to 85.5 kHz |
| | | dog | up to 60 kHz |
| | | cat | up to 64 kHz |
| | | bat | 20 Hz – 120 kHz |
| | | elephant | < 30 Hz |

## Outlook : Push Pull analysis

**1st step:** Pull from the market defines what the customers require regarding assistance, enhancement and expansion of human senses. The available solutions or the technological potential for the creation of solution are assessed (push).

**2nd step:** Two aspects shall be of particular interest: Where do current MEMS excel (available solutions)? Where do natural sensor systems excel (replicable by off the shelf systems)?

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