Hardware Interfaces

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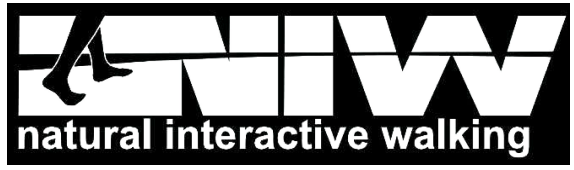
UMPC

Natural Interactive Walking

FP7 IP Project



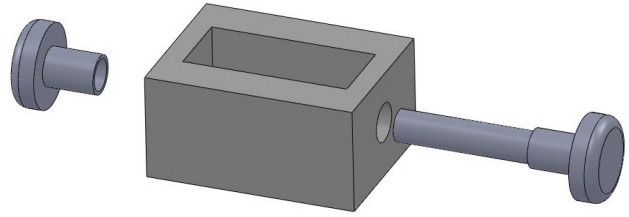
February 2011 Meeting

Main activity for the last period has been focused on:

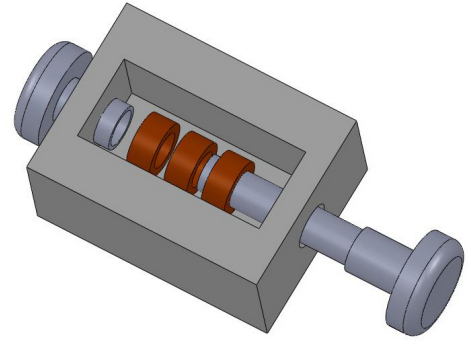
- manufacturing issue of miniature integrated actuators for haptic applications
- prototyping of passive shoe-embedded haptic stimulator
- design of distributed stimulator

Integrated manufaturing process developed:

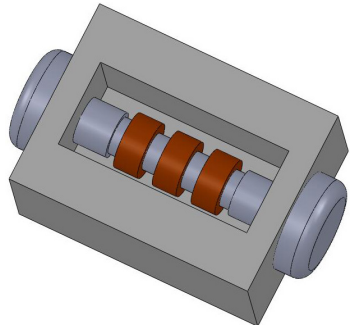
- Mold + plugs preparation:



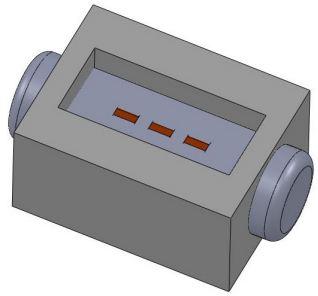
- Locating pre-fabricated coils within 10 μm:



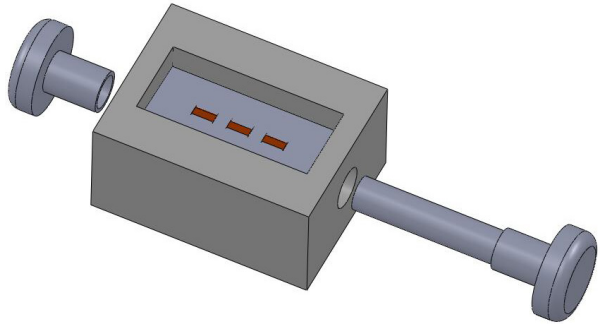
- Prepare bore:



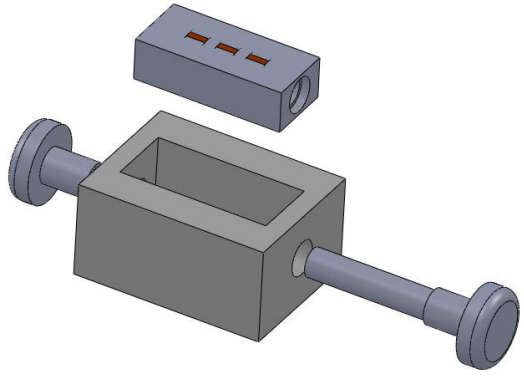
- Pour epoxy compound:



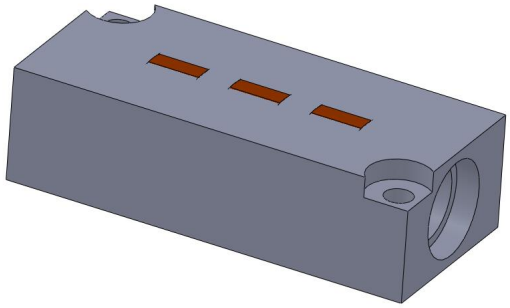
- Cure and create bore:



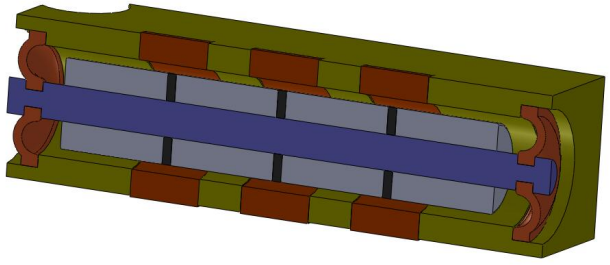
- Unmold device:



- Unolded device (dimentional accuracy within μm):



- Finished device showing all the components μm:



Scaling laws

force

$$F = JBl \tag{1}$$

$$F = 2\pi JBN\frac{D}{2} \tag{2}$$

$$F \propto JND \tag{3}$$

power

$$R = \rho\frac{l}{S} \tag{4}$$

$$l = 2\pi N\frac{D}{2} \tag{5}$$

$$R = \rho\frac{\pi ND}{S} \tag{6}$$

$$R = \propto ND \tag{7}$$

$$P = i^2R = JS^2R \tag{8}$$

$$P \propto J^2DN \tag{9}$$

Scaling laws

motor constant

$$K_m = \frac{F}{\sqrt{P}} \tag{10}$$

$$K_m \propto \frac{JND}{\sqrt{J^2ND}} \tag{11}$$

$$K_m \propto DN \tag{12}$$

$$N = \frac{DL}{S} \tag{13}$$

$$N \propto DL \tag{14}$$

$$K_m \propto D^2L \tag{15}$$

Motor electrical time constant

$$E_m = \frac{Li^2}{2} \tag{16}$$

$$P_{\text{loss}} = i^2 R \tag{17}$$

$$\frac{E_m}{P_{loss}} \propto \frac{L}{R} \tag{18}$$

$$t_e \propto \frac{E_m}{P_{\text{loss}}} \tag{19}$$

$$\phi = J\pi \frac{D}{R_{\text{gap}}} \tag{20}$$

$$E_m \propto \Phi^2 R_{gap} \propto \frac{J^2 D^2}{R_{gap}} \tag{21}$$

$$R_{gap} \propto \frac{g}{Dl} \tag{22}$$

$$E_m \propto J^2 D^3 L \tag{23}$$

$$P_{loss} \propto J^2 D^2 L \tag{24}$$

$$t_e \propto D \tag{25}$$

Thermal resistance

$$D_{th} = \frac{1}{R_{\mathrm{th}}} \tag{26}$$

$$D_{th} \propto DL \tag{27}$$

Stroke

$$F = k\delta \tag{28}$$

$$\delta = \frac{F}{k} \tag{29}$$

$$F \propto JND \tag{30}$$

$$\propto JD^2L \tag{31}$$

$$k \propto \frac{E}{D} \tag{32}$$

$$\delta_{max} \propto \frac{JD^3L}{E} \tag{33}$$

$$\delta \propto \frac{D^3L}{E} \tag{34}$$

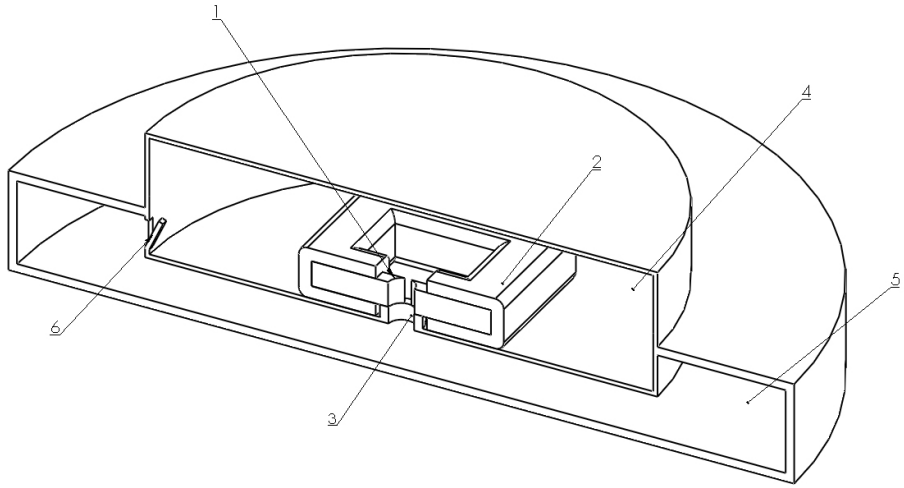
Resonance frequency

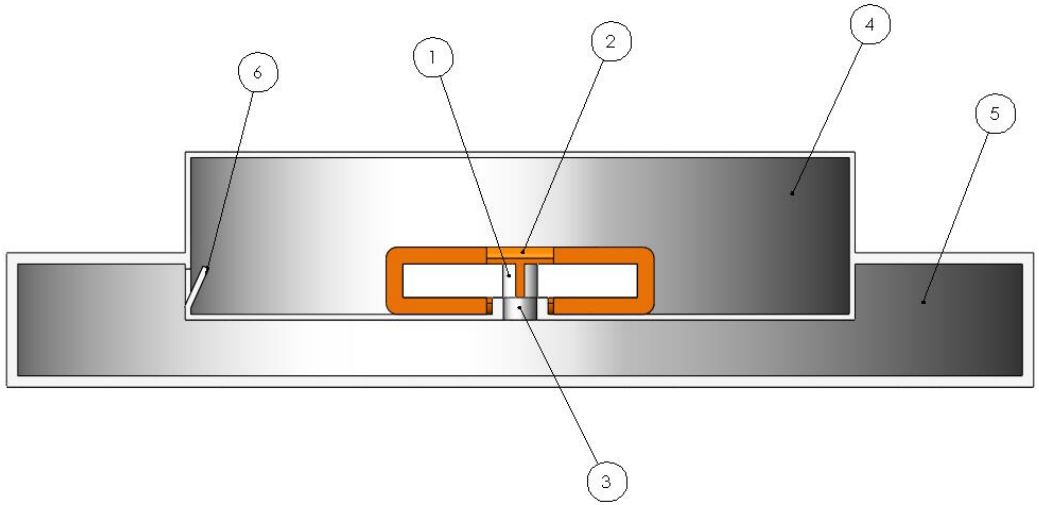
$$\frac{X_{\max}}{F_{\max}} = \frac{1}{\sqrt{(K - M\omega_0)^2 + B^2\omega_0^2}} \tag{35}$$

$$B \propto \frac{E}{D^2} \tag{36}$$

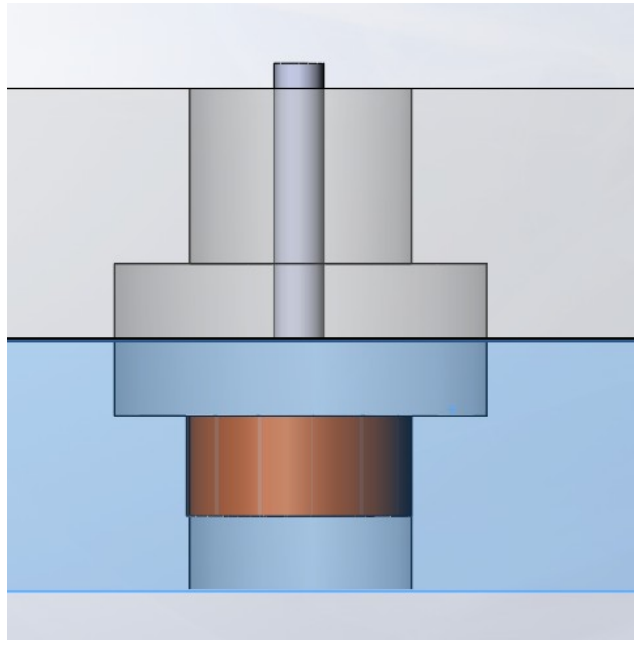
$$0 = \left(\frac{E}{D^2} + D^4L^2\right) - EDL\omega_0 + \left(\frac{E}{D^2} - \frac{D^2}{E}\right) \tag{37}$$

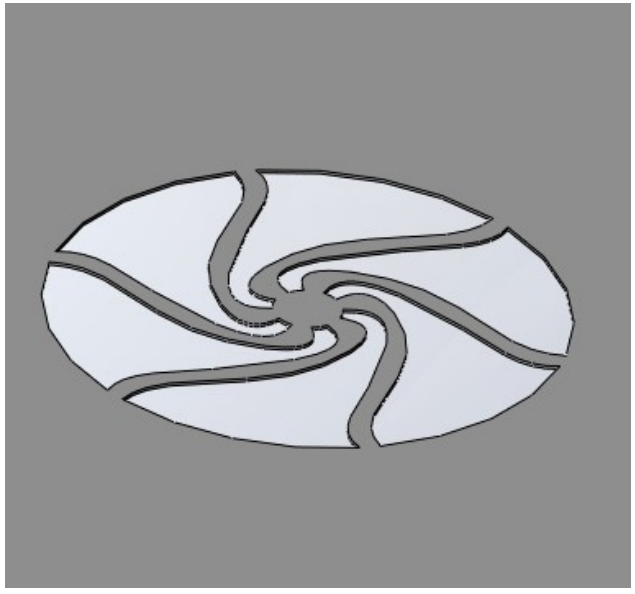
Passive shoe-embedded haptic stimulator

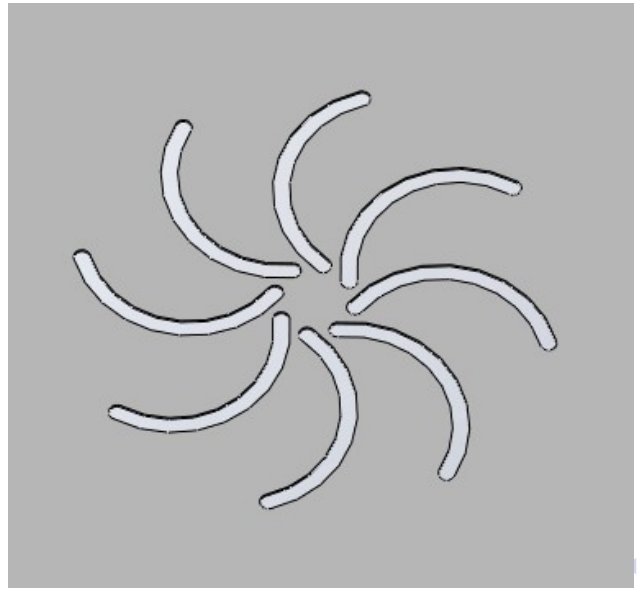




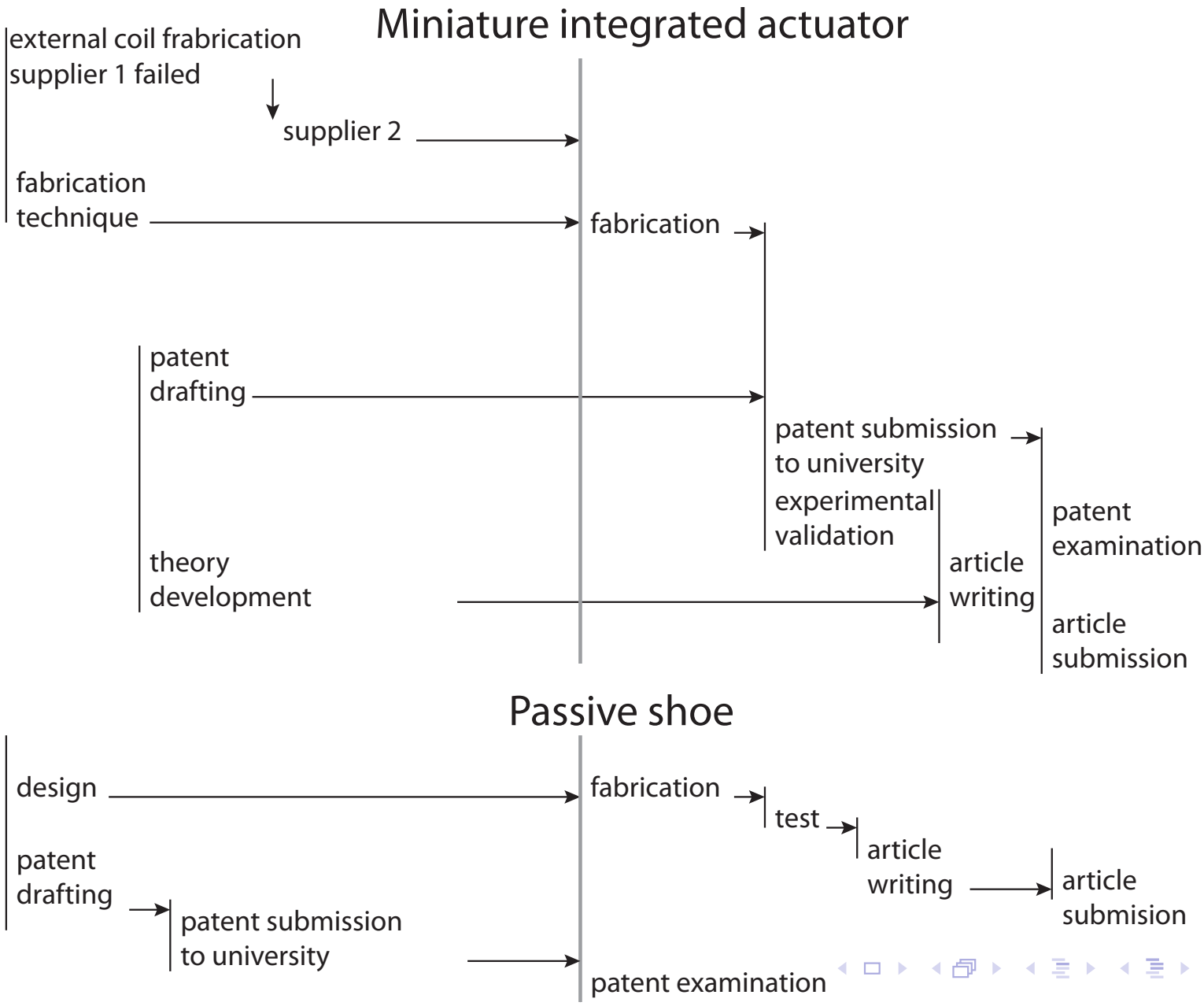
New design for distributed actuator







Time line


Miniature integrated actuator
external coil frabrication
supplier 1 failed
supplier 2
fabrication
technique
fabrication
patent
drafting
patent submission
to university
experimental
validation
patent
examination
theory
development
article
writing
article
submission
Passive shoe
design
fabrication
test
article
writing
article
submision
patent
drafting
patent submission
to university
patent examination