nano-tera.ch Swiss Competition 2015 iCan

iCAN'15 Swiss Contest – Project Abstract

Project Title: **ALASKA BOOTS**

Team Members: **Paolo Micalizzi** (ETH Zurich, Micro and Nanosystems MoS)
Jason Giannopoulos (ETH Zurich, Micro and Nanosystems MoS)
Attilio Ferrari (ETH Zurich, Micro and Nanosystems MoS)
Omar Huerta (ETH Zurich, Micro and Nanosystems MoS)

Coach: **Moritz Thielen** (ETH Zurich, Micro and Nanosystems group)

VISION

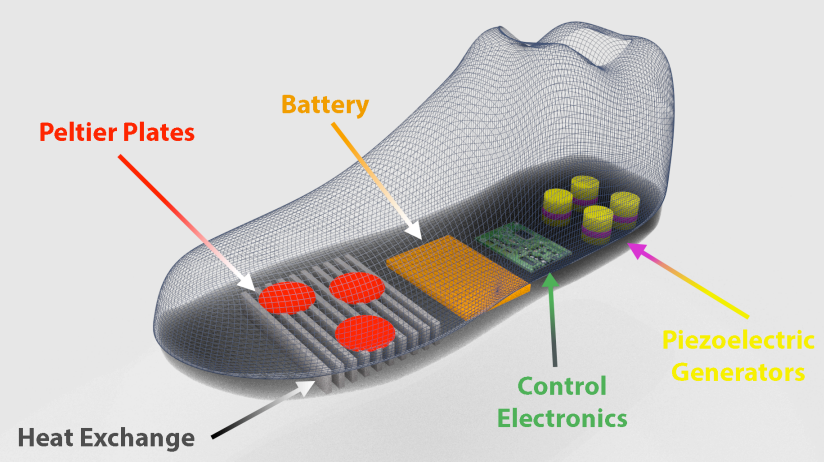
A considerable percentage of the energy produced by mankind is used to control the temperature of our living environment. In Europe this amount goes up to 40%. It is a key priority to optimize this usage in favor of a sustainable solution.

Technological improvements have been made, mainly thanks to new insulating materials and more efficient air conditioning systems, but every day we heat up or cool down entire houses and buildings. Is that really necessary?

Our solution is to scale down the problem, focusing on wearable temperature control systems. We imagine a future in which smart clothes take over centralized air conditioning, providing us with full thermal comfort while harvesting the energy they need from the environment. They will sense our body, sense the environment, understand our level of activity and create for us the perfect microclimate at any given time.

PROPOSAL

Following our vision, we want to enhance a regular pair of shoes by integrating Peltier elements in the insoles. The user will be able to tune the temperature perceived by his/her feet without affecting functionality and style of his footwear.



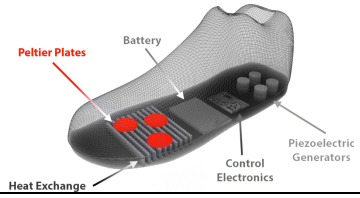
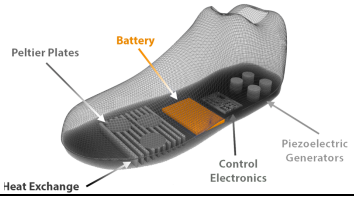
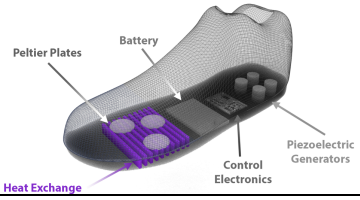
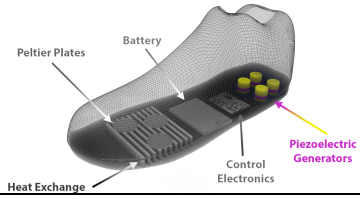
WORKING PRINCIPLE

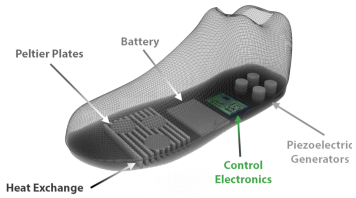
An integrated battery powers the modules. To reduce power consumption, heat pulses instead of a constant heat flux are applied to the foot. It has been demonstrated that the brain perceives a higher/lower temperature than the actual one when the body receives "hot"/"cold" pulses in strategic locations. With a zero-power system as long-term goal, an energy harvester is also implemented.
A custom-made thermoconductive shoe sole provides the heat sink required to dissipate heat produced by the Peltier elements. A temperature sensor controls pulse intensity and an accelerometer controls its frequency so to match it with the step and actuate the plates when the foot has the best thermal contact with the sole.

MOTIVATION

We choose shoes because it is a simple and effective way to demonstrate our idea.
Shoes are not very weight sensitive, there is enough space to integrate all the components, and they can easily protect the parts used. We use Peltier plates because, although not very efficient, they are portable, resistant, they do not require liquid coolant or complex ventilation systems.

DEVELOPMENT PLAN

MAIN TASK	SUB-TASKS	COMPONENTS	COST (CHF)
COOLING and HEATING 	- Peltier plate sizing and positioning - Selection of commercially available plates - Pulses study	- 2x Peltier modules	100
POWER SUPPLY 	- Power requirement study - Battery selection - Hot/cold/off switch design - Components positioning and protection study	- 2x Battery - Battery charger - Switch	60 30
HEAT SINK 	- Heat generation/dissipation study - Identification of suitable thermoconductive material - Heat sink design	- 2x Heat sink	50
HARVESTING 	- Harvesting feasibility study - Harvesting method selection - DC/DC conversion circuit design	- Harvesters - 2x DC/DC converter	30

CONTROL SYSTEM 	- Connect the microprocessor to sensors and power source - Program the processor to generate PWM signal for pulse actuation	- 2x Microprocessor - 2x Temperature sensor - 2x Accelerometer	50 10 10
PROTOTYPING	- Implementation of all selected solutions in a pair of shoes	- Shoes - Various tools and components	100 60

Total: 500

TIMING

MAIN TASK	SUB-TASK	MONTHS (2015) 1	2	3	4	5
COOLING and HEATING	Peltier plate sizing and positioning	■				
	Peltier plate selection	▼				
	Pulse study	■				
POWER SUPPLY	Power requirement study	■	■			
	Battery selection		▼			
	Switch design		■			
	Position and protection study			■		
HEAT SINK	Heat generation/dissipation study	■	■			
	Material selection		▼			
	Heat sink design			■	■	
HARVESTING	Harvesting feasibility study	■	■			
	Harvesting system selection		▼			
	DC/DC conversion ciruit design			■		
CONTROL	Pulse circuit design	■	■	■		
	Temperature sensor integration			■		
	Accelerometer sensor integration			■		
PROTOTYPING				■	■	■

First month tasks in details

1. We will select brand, size and most effective position of the Peltier plates by building a test setup. Different Peltier plates (already available in MNS lab) will be connected to a function generator and attached to a simple support to physically test the heating and cooling "feel" on our feet.

2. Thanks to the function generation we will test different PWM inputs and select optimal amplitude and frequency.

3. We will roughly estimate power requirements based on test results in order to confirm that a portable consumer grade battery can power the system.

4. We will collect data on heat produced/absorbed by the outer side of Pelter plate (side not in contact with foot) for later heat sink design.

5. We will estimate if adding an energy harvester makes sense