What if… people could sense the air pollution around them?

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Designing a wearable item that informs the user/those around them about ambient air pollution concentrations to draw awareness towards an invisible hazard we are almost constantly exposed to.

The Problem….

In developed countries, air pollution has changed from the acute, visible, tangible smogs experienced by Europe and the US up to the 1970s, into an invisible, but more toxic threat to health.

In developing countries, air pollution is highly visible and so pervasive, there is little way to escape it.

In the West, pollution concentrations vary hugely from street to street, but there is little public understanding of the risks, or way to find out and learn about it, and yet 400,000 premature deaths occur in Europe from poor air quality every year.

Provision of digital/numeric information has, to date, been unsuccessful at providing users with readily interpretable air quality information based on their precise location. The proposed wearable tries to translate abstract figures into simple, tangible feedback. While the wristband actively senses the environment it reacts accordingly. Subtle compressions in the wrist area will alert the wearer upon entering areas of higher air pollution. The wearable deliberately avoids any visual indicators or display of environmental data.

The mockup also served as a platform to speculate upon embedding active and responsive biomaterials at a yarn-level which could serve as biosensors equipping the wearer with an additional sense.

Choice 1: Communicate air quality to:
a) individuals or b) those around them?

Whilst it might be more desirable to communicate information between the individual with the device and those around – creating a social link between exposed and emitter (i.e. “we” are in a polluted area), the scale of the task and time allowed prompted the design of a device for an individual.

For further discussion on tensions between targeting air pollution interventionsat individuals or wider society see:

- Chatterton, T. (2017) Air pollution: Putting people at the heart of the issues. *Environmental Scientist*, 26 (2). http://eprints.uwe.ac.uk/31825/7/Chatterton_es_clean_air_Apr_17.pdf
- The EU ClairCIty project (Citizen Led Air Pollution Reduction in Cities) www.ClairCity.eu

Personal AQ App on Smart Phone PHOTO: JACOBS SCHOOL OF ENGINEERING AT UC SAN DIEGO

Public message board with AQ information (Philippines) PHOTO: HTTP://AUTONIXENTERPRISE.COM

Choice 2: Mode of Communication

How should pollution concentrations be communicated?

Examples of other devices include:

Home Energy Displays, or conventional air pollution apps – these usually provide visual, numeric information that requires direct engagement (e.g. stop to look) and rational processing/ interpretation of quantitative/qualitative information

Example of Home Energy Display PHOTO: HTTP://GREENTECHADVOCATES.COM

Fitbits – provide little in the way of immediate information – other than tactile 'buzz' at 10,000 steps

Example of self-monitoring fitness bracelet PHOTO: AMAZON.COM

Decision made: provide a haptic device, to indicate changes in levels of air pollution (through gentle constriction). Allows non-intrusive communication.

Bonus – this method reduces the challenge of accuracy and precision for personal monitoring devices

Choice 3: What type of device?

Final decision = Bracelet, easy to remove, allows visual as well as haptic component to be added to add further information (on pollution, time, etc.)

Other options considered:

Necklace – particularly with use of constriction, this was judged potentially threatening, also limits option for visual component for the wearer

Garment – more suitable for incorporating communication of information to those around the wearer (see Choice 1)

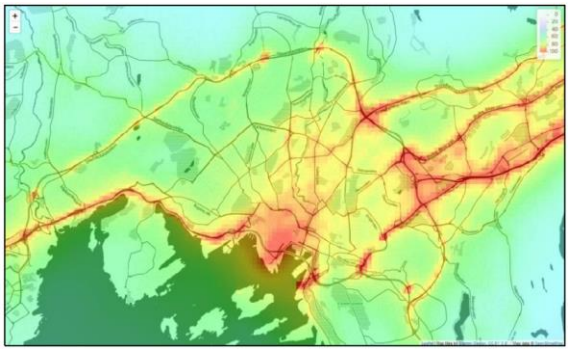
Socks – potentially suitable for providing haptic information on direction towards cleaner air, but limited visibility to wearer and others

Choice 4: How to provide air pollution information to the device

Use in built or on-body sensor for air pollutants (*cheap sensors currently unreliable*)

Example of current transistor size AQ sensors PHOTO: HTTP://WWW.LIBELIUM.COM

Use modelled air pollution map (via web or on phone) and estimate pollution using GPS (*requires external information*)



Example of mapped/modelled air pollution data for Oslo PHOTO: HTTP: CITI-SENSE

Use biological material that reacts and constricts naturally in response to higher levels of pollution (*material currently unknown*)

Example of air pollution damage to plant PHOTO: NASA EARTH OBSERVATORY

OPTION TAKEN: Design device to be capable of taking information from either A or B.

Consider C for future development

Choice 5: Materials and mechanisms

Ideal choice: Self-sensing bio-material (see Choice 4)

Next best: Entire bracelet made of memory material that would constrict on activation by low voltage/current supply of power (see example flexible 3D printed bracelet Prototype A)

PHOTO: CHATTERTON/BEYER

Trial 1: Material bracelet with memory wire insert, constricting on supply of power – the available wire required too high a current and got too hot

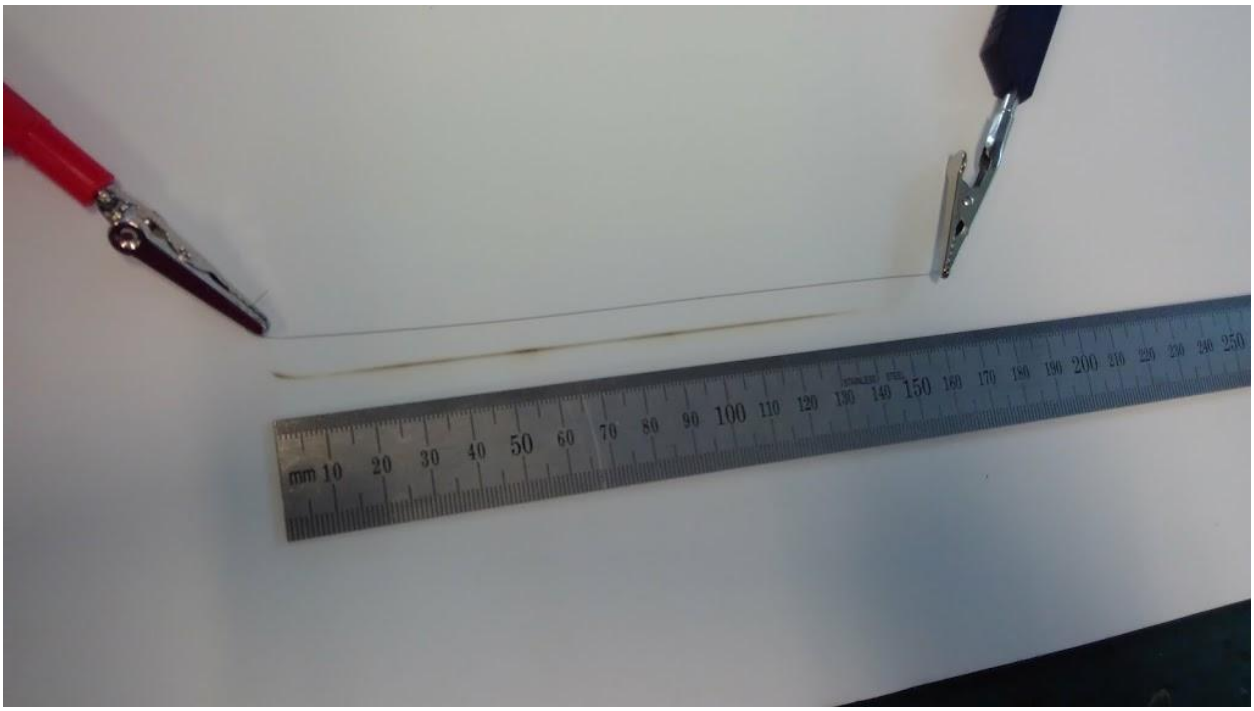


PHOTO: CHATTERTON/BEYER

Prototype B: Material bracelet with constriction driven by micro-servo from Arduino circuit board

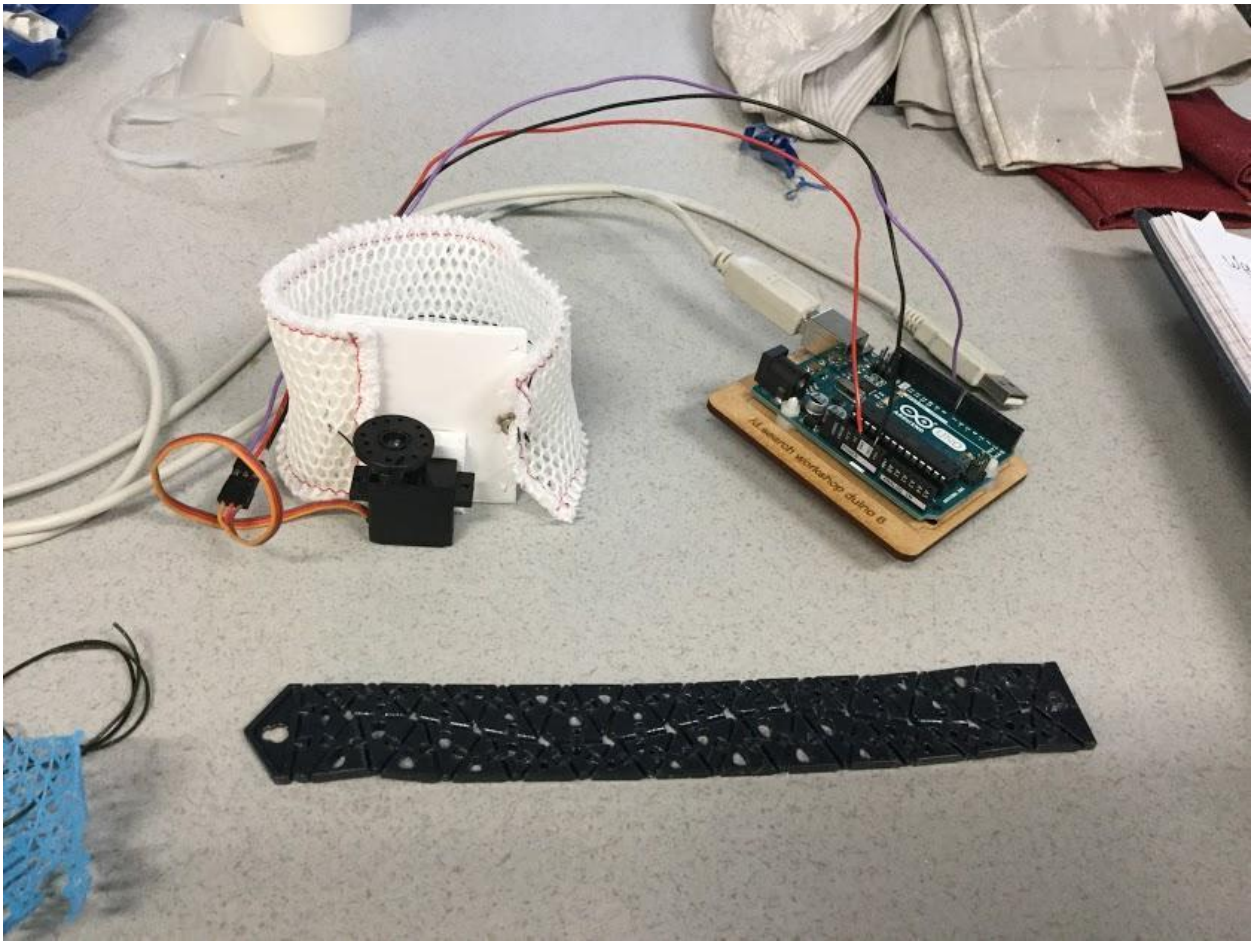


PHOTO: CHATTERTON/BEYER

Conclusion: Whilst lacking aesthetics and somewhat bulky, the prototype would allow full testing, particularly of specific communication messages (see Research Testing)

Research Testing:

There are three key research questions to test with the device:

What haptic messages do users find most useful in interpreting the air pollution around them? e.g. constant increasing constriction proportional to concentrations, or pulses representing concentrations (more pulses = more pollution).

How do (should?) people react to being given the information? e.g. Begin to avoid heavily polluted areas in order to protect their own health? This could be through instant reaction to messages, or through using the bracelet as tool to understand and learn about their environment, leading to new patterns of behaviour rather than just reactive actions to avoid pollution hotspots.

How can a greater understanding of both personal exposure and spatial patterns of air pollution help people to realise extent of the air pollution problem and create action/pressure for social change? Noting that there is little that can often be done in terms of individual action other than reduce exposure, but the role of the individual may be more appropriate being targeted at political and societal change.

Possible future developments

Providing information steering wearer to nearest clean air e.g. by constricting device more on one side than the other (possible using spatial GPS method (Option B in Choice 4).

Providing other visual information (e.g. actual pollution concentrations) when wearer wants to look at device.

Developing organic materials that react to pollution in order to remove need for external sensors/data

Sources of Inspiration

Tensegrity Structures

PHOTO: CHATTERTON/BEYER

Fungal Biostructures


PHOTO: CHATTERTON/BEYER

Contracting Memory Materials

PHOTO: HTTPS://WWW.BEADALON.COM/

Flexible 3D Printed Jewellery

PHOTO: HTTP://N-E-R-V-O-U-S.COM/KINEMATICSHOME/

Anatomical Reactions to Air Pollution

Acute response of the lungs
1- Airway reactivity

- Bronchi contract so decrease the amount of the air comes to the lung- trapping what comes to the lung
  - Smoke, dust, air pollution

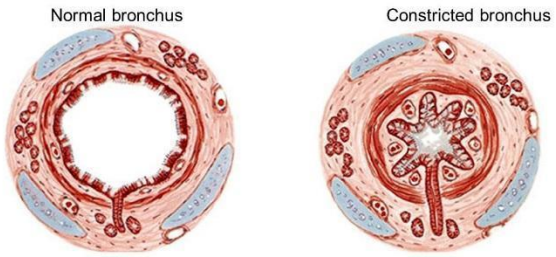


PHOTO: DR B DAMIIRI HTTP://SLIDEPLAYER.COM/SLIDE/10885073/

Key moments in Design Process

Move from provision of numeric/quantitative information to haptic communication:

- Removes need for accuracy/precision
- Allows constant provision of information, not just when wearer visually engages with device
- Provides a metaphorical connection to the unsensed constriction of airways caused by air pollution

Linking of our two research areas: air pollution and use of fungal structures to convey environmental information

Availability of materials (3D printer, spacer material, memory wire, micro-servos/Arduino)

Other issues of interest arising

Complexity vs simplicity – both of mechanics and of messaging

Information vs advice – to what extent should the device suggest a normative action?

Connectedness vs Stand-alone operation? Are benefits of connectedness (including external logging and compiling of data from many devices worth the additional complexity)