Snowflakes: A Design Speculation for a Modular Prototyping Tool for Rapidly Designing Smart Wearables

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Abstract
Aesthetics qualities are critical aspects for smart jewelry as they are worn and considered as expressive artefacts. However, current tools for prototyping smart jewelry do not put aesthetic considerations as a primary concern. Therefore, we created Snowflakes, a design speculation for a modular, "snap-on-off", prototyping tool for designing smart jewelry. The design requirements of Snowflakes were determined after studying non-smart jewelry and extracting 7 parameters for them (*limb, material, grip, fastener type, decoration, decoration placement and form*). Drawing upon these parameters, *Snowflakes* were proposed as a tool that would allow prototyping smart jewelry by synthesizing conventional jewelry's form language with smart jewelry which is adorned with technology. This paper explores using this product as a design tool to experiment on designs blending aesthetics and function.

Author Keywords
Wearable; smart jewelry; design speculation

ACM Classification Keywords
H.5.2 - Input devices and strategies - Interaction styles

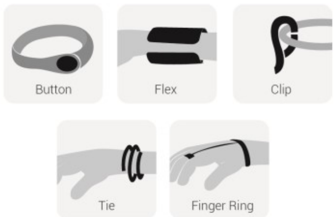

Figure 1: Fastener types

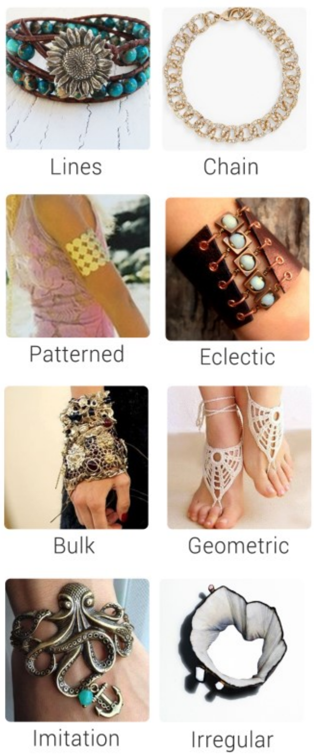

Figure 2: Form parameters from our investigation database (images taken from pinterest.com)

Introduction

Smart wearables have come to be an integral part of our lives. Until recent years, the primary considerations when designing smart wearables were functionality and computational power. However, in the last decade there has been a shift of focus towards considering aesthetic concerns and personal expressiveness in smart wearable design. In one subsection of smart wearables, there is smart jewellery for which aesthetic expectations are very high [8]. The appeal of a piece of smart jewellery can commensurate with its visual design similar to non-smart jewellery since both are worn and displayed on the body as a personal artefact [11]. As a result, these pieces of accessory have to fulfil aesthetic, personal and social expectations [8].

For designers to overcome the task of maintaining functional capabilities while designing an aesthetically pleasing and ergonomic device, certain design approaches are used. Some of these approaches include iterative design involving user tests with interactive prototypes to streamline the creative process. As such, many toolkits which target the non-technical population have been developed. These toolkits allow for creating or testing basic functionalities of smart wearables without the need for extensive technical experience. Such toolkits commonly include power sources, processing units, connectors, sensors and actuator units [6]. However, the toolkits developed thus far have focused either on testing out functionalities or providing an educational platform. The educational toolkits include ReWear [7], iCatch [10] and EduWear [6]. Among the toolkits created for e-textiles are LillyPad [4], Flora [1] and others [5]. Other works concerning similar concepts are bYOB [9] and LittleBits[3]. Even though these toolkits are extensive, there is still a gap in terms of smart jewelry toolkits for designers to experiment on aesthetic concerns as well as functional ones since existing ones does not correspond with the form language of jewelry design.

To fill this gap, we first analyzed the non-smart jewelry and extracted 7 parameters to assess them. Drawing upon these parameters, we propose Snowflakes as a design speculation for such a toolkit. We believe that such tool kit can help smart jewelry designers to experiment on different expressions which can blend aesthetics and extended functionalities.

Design Parameters for Existing Jewelry

Snowflakes are imagined with certain form getting capabilities in mind. We examined more than 270 different non-smart jewelry over Pinterest.com and laid out 7 parameters for categorizing them (samples can be reached from bitly.com/wearthefun). These 7 parameters are *limb, material, grip, fastener, decoration, decoration placement and form*. A non-smart piece of jewellery can be assessed on these 7 parameters to become inspiration for smart jewellery. These parameters are listed below:

- *Limbs* parameter is concerned with which limb the accessory is worn on.
- *Materials* parameter is used to categorise accessories according to their materials like gold, silver, leather, rope, wood etc.
- *Grip* parameter refers to the fit of the accessory. It can be categorised as tight if it fits snugly around the limb or loose if it has a more relaxed fit.
- *Fastener* (Figure 1) parameter classifies jewellery according to different fastener types. Subcategories of this parameter are buttons, clips, ties, finger rings

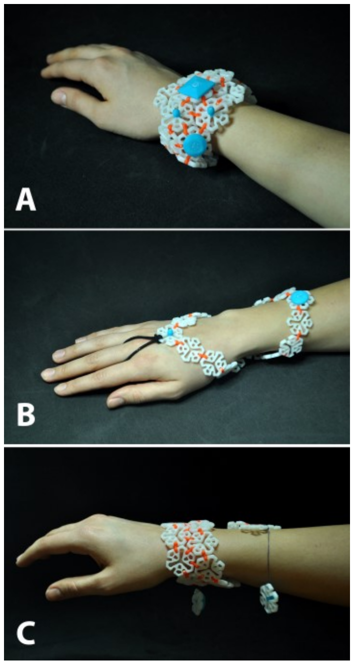

Figure 4: Different Design Alternatives that can be created by Snowflakes

Parameters:

A) Arm, plastic, flex, electronic and geometric shapes, static, bulk

B) Arm, plastic, finger ring, electronic and geometric shapes, static, chain

C) Arm, plastic, flex, electronic and geometric shapes, dynamic, lines

and flexing of the accessory itself in order to fit around the limb.

- *Decoration* parameter refers to the material and form of decoration that is on the accessory. Its categories are non-precious, semi-precious and precious stones, pearls, seashells, metal pieces, metal figures, strings, cloth figures, glass figures, plastic figures, feathers, chains and embedded shapes.
- *Decoration Placement* parameter stands for the position and the arrangement of decoration pieces on the jewelry. *Static* refers to fixed objects while the *Dynamic* represents moving objects such as dangling parts.
- *Form* parameter (Figure 2) categorises the form of traditional jewellery into 7 different categories. These categories are lines, chain, eclectic, imitation,
  - Lines: Adornments that have continuous lines in their forms
  - Chain: Adornments having a chain assembly as a main body
  - Eclectic: Consisting of distinct pieces as a base structure,
  - Imitation: If the form of the adornment is a direct transfer from a real-world object like a flower, sword, etc.
  - Patterned: Adornments that are consisted of patterns
  - Bulk: Adornments which are designed with pieces brought together as a mass
  - Geometric: Geometric shapes like squares or hexagons are used in the jewelry multiple times
  - Irregular: If the lines which form the shape are not in regular pattern, it is classified as irregular

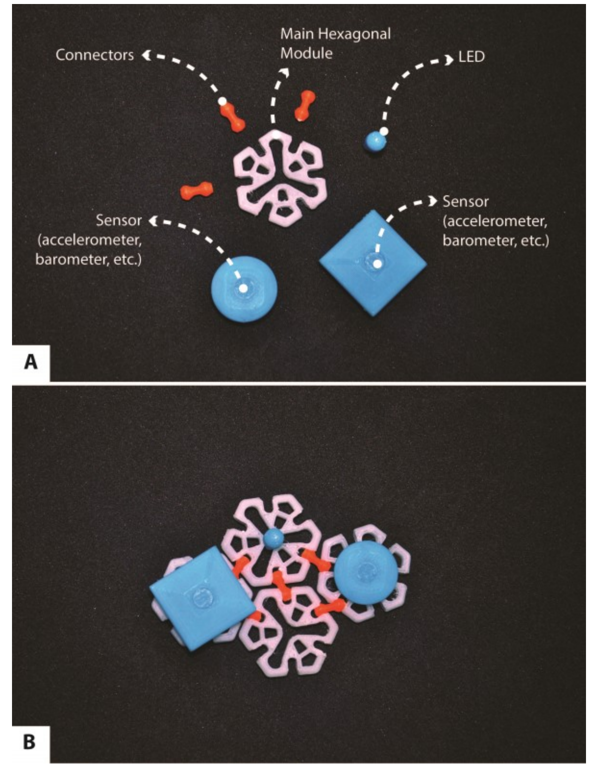

Figure 3: A) Parts of the Snowflakes B) Assembled state of the Snowflakes

These parameters helped us in the ideation process of the smart jewelry prototyping tool, Snowflakes.

Design of Snowflakes

Snowflakes include hexagonal modules, spherical headed connectors and models for microprocessor module, sensor module and actuator module as demonstrated in Figure 3. Each hexagonal module can be connected by maximum 6 connectors. Each connector joins two modules. The modules are snapped together and apart using the connectors.

The spherical connectors of Snowflakes allow the assembled piece to behave flexibly like a chain or fabric would. The fabric like property allows increased freedom in creating different textures compared to more rigid structures. This was not possible in similar toolkits which required sewing on fabric or using cable connectors. Experiencing the freedom of a chain expands the possibilities of creating prototypes that are closer to the finished product.

The snap-on-snap-off property allows for reusability and opens up space for trial and error. In the process of designing Snowflakes, many different shapes of connectors were tested. The spherical headed connectors were chosen to achieve the fabric like flexibility. The modules can be connected in an almost infinite number of combinations to create different products and to test out different form factors.

Several different form factors which can match to our parameters are demonstrated in Figure 4. We also defined the parameters which fit our designs. All our examples are worn to arm, hosts electronic and geometric decorations and uses plastic as a material. These can be varied with further production techniques (i.e. production from different materials, covering snowflakes with other materials, 3D printing different decoration shapes or wearing these designs to other limbs, connecting different fastener types). These three examples in Figure 4 can be increased with many more by using different combinations. This shows that Snowflakes can be used by designers to prototype many different smart accessories and wearables.

Implementation Plan

Design speculation should form a bridge between the concept and the perceived world [2]. Thus, in this section we present the implementation schemes of Snowflakes and explain the workflow for the end users. A key part of the Snowflakes concept is the sphere-headed connectors which can move freely and carry complex sensor information. Instead of working on a single connector type that is capable of carrying different types of data, we will design two types of connectors, which are conductive and non-conductive. While the conductive ones used for connecting input and output modules using I^2C protocol and for providing power and ground for circuit elements, non-conductive ones will be used for connecting Snowflake modules for visual/formal concerns.

Making jewelry “smart” includes adding logical responsivity and wireless connectivity features. Snowflakes uses two, three or multi-terminal electronic devices such as temperature sensors (i.e. Texas Instruments’s TMP103 with 2 pins for data read-out, one pin for power and one for ground), motion sensors (i.e. STMicroelectronics’s LIS2DS12 which can record movement data characteristic for each different motion type and help identify user mood) as well as Bluetooth transceivers (i.e. Texas Instruments’s CC2540). In addition, the building blocks include surface-mount light-emitting diodes soldered on printed circuit boards (PCB’s) with small footprint. These small pieces of PCB’s provide small modular elements that include the peripheral resistor/capacitor circuitry. All sensors use at most 5 Volts, therefore a single coin battery (from small SR41 to SR55) is sufficient to power the sensors.

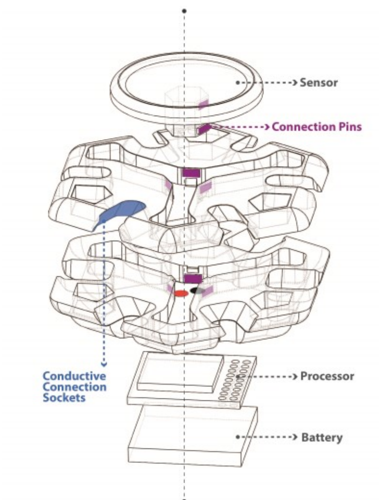

Figure 6: Exploded perspective which shows the components of a Snowflake Module

In Snowflakes, each sensor is embedded in the same module with its own inexpensive and miniature CC2540 microcontroller and peripheral electronic circuitry enabling designers to focus and iterate on form instead of debugging functional errors. Snowflakes provides modularity by simplifying electronics design, sensor data acquisition and wireless connectivity, which can be rapidly tested by designer.

Figure 6, shows a diagram of a Snowflake block, that combines a motion sensor (accelerometer), a temperature sensor, an LED and several empty Snowflake modules. As shown in Figure 6, each Snowflake module includes a processor for integrating input components such as sensors or output components such as LEDs. Ground and power connections that are presented as black dots taking part at the bottom of the socket. In Figure 6, purple pins are dedicated for input and output components and are directly connected to processor. On the outer parts, there are three different types of connection sockets: Input (I), output (O) and bypass (B) sockets. With input and output sockets, modules can get or send data from/to other modules through I²C protocol. Bypass sockets are for providing connection without interfering with the next module's processor. In Figure 6 - b, temperature sensor provides data to motion sensor directly. The data going out from the motion sensor bypasses two empty modules and reaches to the module with an LED. As seen, red connectors are conductive and carry data while the black ones are used for connecting modules only physically.

To program certain actions, we will also design a computer interface which will include a block-coding language. Main output module (the module with the LED) will connect to the computer over Bluetooth and

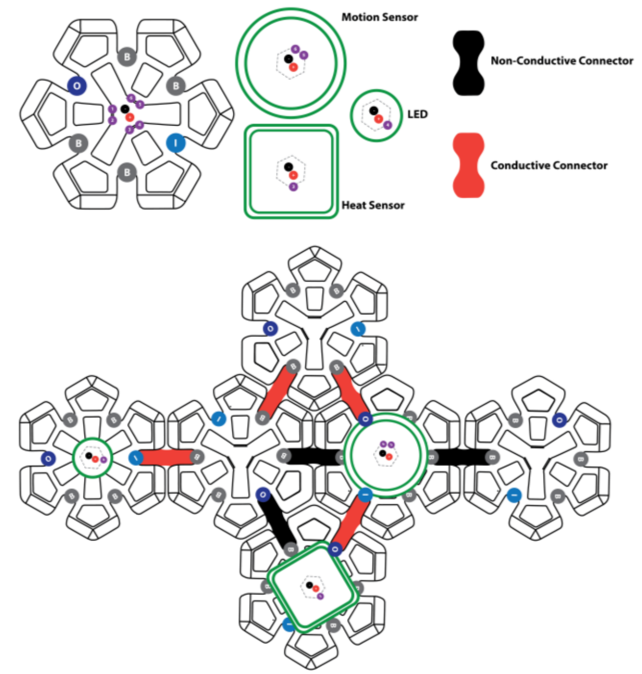

Figure 5: (a) Proposed components of Snowflakes, (b) an example Snowflake Block

interface will recognize the attached sensors by interpreting the messages (each different sensor will send a message to the output module with a certain flag). Then, users will be able to program these sensors by using the block-coding interface.

Conclusion

Snowflakes toolkit speculation was proposed to fill a gap in the library of tools that allow for prototyping smart wearables and especially smart jewelry. This tool is expected to allow a certain level of freedom to test out different forms with modular connectivity. We examined the already existing works, defined a set of parameters for jewelry design and created a non-working prototype as a design speculation according to those parameters. We also presented our implementation plan and steps for turning this speculation into an actual working-prototype. We believe that Snowflakes can be a valuable tool for smart jewelry designers to create new expressions which can blend aesthetics and functionality. Moreover, our design parameters which were set to create this concept can inspire and guide designers and researchers of the smart jewelry.

Limitations and Future Work

For future research, workshops with jewellery designers are going to be conducted to identify major use cases. Then, we plan on demonstrating each electronic hardware and software module and compiling a library of sensor/microcontroller pairs with their packaged module for Snowflakes. After implementing and testing a functional set of modules, a visual software programming and iterative design interface is going to be implemented. A hardware and software library of packaged electronic sensor/microcontroller pairs (such as microcontrollers, Bluetooth transceivers, LED's, resistors, capacitors, batteries of different sizes) are going to be available for plug-and-play testing by designers and a software kit for 3D visualization is going to be implemented. After the production of the artefact, we are also curious how this can serve as a medium that can start a discussion on social, cultural and ethical implications of existing and emerging technologies.

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