VISUALISATIONS THROUGH KNITTED STRUCTURES

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Abstract: Information visualisation has long been used to convey messages and ideas, from the abstract to the very concrete. Data of different types and natures are conveyed mainly using visual images and color coding. Historically, this began in ancient times with cave paintings and pre-literate methods of information transmission. Nowadays, information is easily accessible, literally everywhere, and its visualisation is used in science, business, education, entertainment, everyday life. Information visualisation and its infographics have become very popular. This article presents the use of knitted structures to visualise information and the analysis of the composition of yarns, their properties and their ability to take different forms. A significant number of scientific and artistic interpretations of knitted structures created for the purpose of information visualisation are considered.

Keywords: knitted structures and meshes, data visualisation, data interpretation, colour coding

INTRODUCTION

Machine-made knitted products are one of the first industrial productions. In recent years, there has been a trend of increased demand for knitted textiles, as they most easily and quickly allow for product customization, which is increasingly sought after by modern consumers. The life cycle of these products is very long, they are subject to recycling and processing, which, in turn, is in full accordance with the trends for slow and sustainable fashion and circular economy. Innovations in the field of production and use of textiles relate to the creation of models from materials of different composition that can respond structurally to changing conditions. Textiles are relatively cheap, strong, light and recyclable, and this allows for various predictions of their behavior, which makes them attractive for various studies and simulations, including the behavior of textiles for animation and computer graphics (Karmon, 2018).

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OVERVIEW OF VISUALISATIONS THROUGH KNITTED STUCTURES

For both virtual products and real products in industrial, interior and fashion design, it is very important to depict textiles realistically, both in the form of fabrics and knits. In knitting, the task of depicting is a little more complicated, since the yarn is composed of fibers with different parameters such as: composition, twist degree, thickness, knit type, and hence its different behavior. 3D models are used to study the behavior of knitted structures, since the visualisation of the 3D structure of knitwear and knitwear allows for the creation of a virtual design with options for easy modification of various parameters of knitted structures until the optimal one is achieved for the specific task. Groller, Rau and Strasser (Groller, 1995), for example, present a method for modeling and imaging knitting by representing the yarn microstructure as an approximation through volumetric data sets. That method allows for clear and flexible control of both the yarn and the entire knitted fabric, which in turn allows for relatively fast virtual design and prototyping with high-quality representation of the results. This leads to savings in time and costs of real material.

Woven structures are used in artistic ways to convey and visualise information in what is known as data physicalization, which is the act of creating visualisations of data in a physical space. Jones et al. (Jones, 2024) present the specific physicalization of data on art gallery visitors during the year of recovery from the COVID-19 pandemic through the installation "The Life of a Building," commissioned by the Art Gallery of Ottawa (Fig. 1).

Fig. 1. The installation named "The Life of a Building", commissioned by the Ottawa Art Gallery

To create the installation, visitor data were collected in the period July 2021-2022 via an ultrasonic sensor at the entrance, which transmits information about entering visitors to a circular knitting machine. The color of the yarn, which changes every month, physicalizes the visitor data and "accumulates" over the year. The corresponding data is presented in an expanded form through an infographic (Fig. 2), where every individual month can be seen. The resulting woven structures are exhibited subsequently in the gallery as an installation.

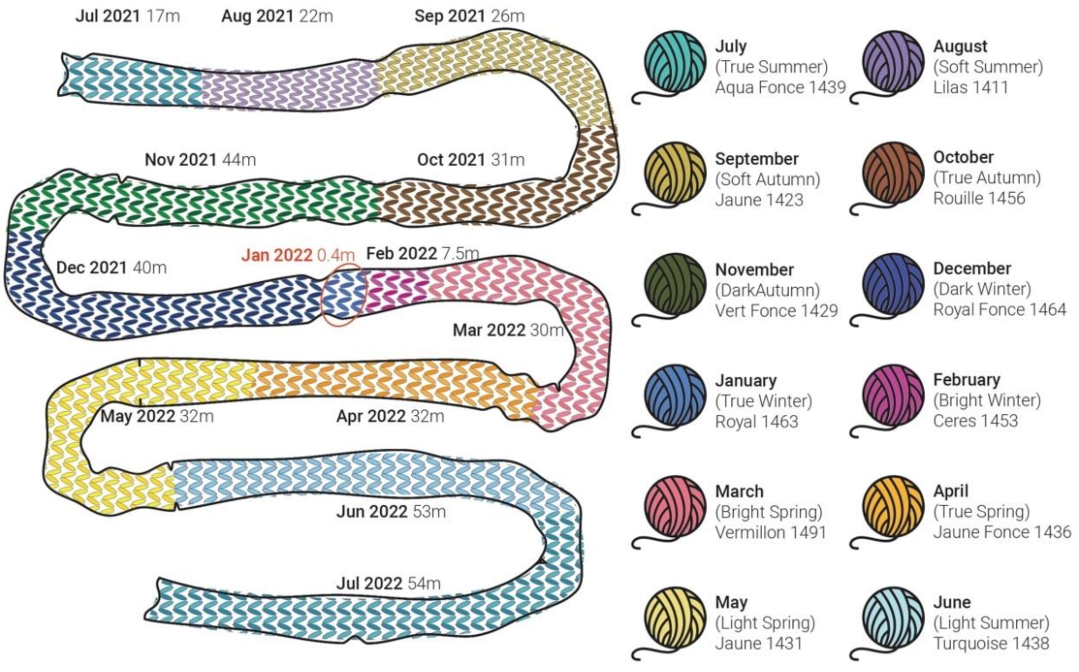

Fig. 2. The illustrative summary of the data

Another unconventional use of knitted structure visualisation is described in (Hinze, 2022), who present physycalization for a digital library and e-books using a knitted scarf. Initially, they create a digital prototype, the visualisation data is obtained by exporting metadata from an audio collection of audiobooks and using three characteristics: genre, book length (measured in minutes), and acquisition order, thereafter the data is transferred to a knitting machine and creates a prototype of the scarf (Fig. 3). The convenience of knitting here is expressed in the ability to convey information simultaneously through several visual representations:

- the color coding of different genres shown as separate bars of different width;

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- the use of texture, different of knit types and yarn thickness again to convey different categories of information;
- adding knitting to the product when the library acquires new books.

Fig. 3. Knitted prototype of a library collection

This data presenting allows communication between people, as well as discussions about different genres of books among bibliophiles by comparing the type and size of the stripes representing each collection.

In scientific terms, in areas such as actuators and sensors, solar cells, etc. the visualisation of knitted structures can be used to study the behavior of various objects when transforming their shape. Such a concept, called knitmorphs uses 2D knits consisting of yarns of different materials and transforms them into various three-dimensional shapes. Through this concept, potential applications of programmable knits are proposed for the development of robots based on jellyfish-like locomotion and complex structures similar to wind turbine blades. The simulated knitted models achieve geometric shapes such as a turbine blade, which are relatively more complex than simple disks or planar shapes limited to soft, thin sheet materials that are easily deformed (Rout, 2022). The initial basic knitted sample is developed using different knits and data is obtained on its behavior under different deformations (Fig. 4) The aim is to introduce a new design field considering transforming structures.

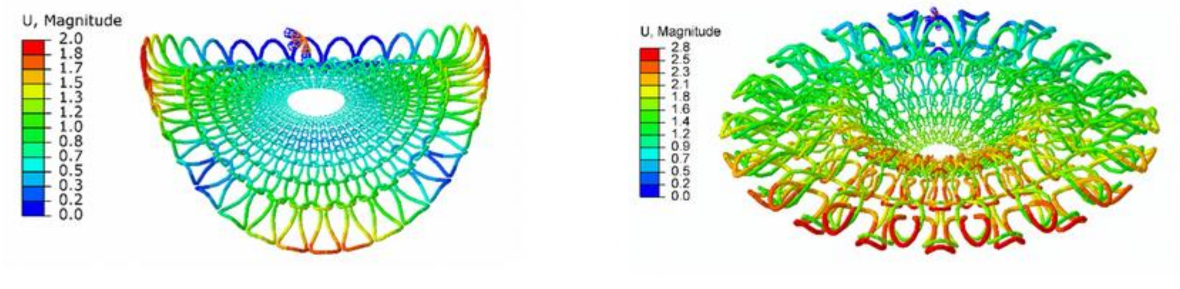

Fig. 4. Knitmorphs: numerical simulation of knit based morphable structures

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Colour coding is used for the different values, which are studied – thermal, geometric, axial and radial deformations along the axes. These knitted structures show potential for subsequent creation of complex shapes from other materials. Knitted structures resembling fractals can be used in the design of textiles with specific applications – in smart wearable devices based on fabrics, for sweat regulation for example.

Another study, related to the ergonomics and physiological comfort of protective clothing, is presented in (Skrzetuska, 2021). Biophysical properties of three-layer textile sets differing in geometry and composition of raw materials for the production of mummy-type sleeping bags for premature babies are being studied. Air permeability, thermal resistance, water vapor resistance, and thermal insulation were measured using models and mannequins. The main goal is to provide guidelines for ensuring physiological comfort of the newborn through optimal heat and mass exchange between his skin and the environment. In addition, the weight of the fabric is also an important factor - it should be as low as possible, since the skin of the premature baby should not be stressed (Skrzetuska, 2021).

EXPERIMENTS

In 2019 the authors of this paper together with colleagues from the Faculty of Power Engineering and Mechanical Engineering of TU-Sofia conducted a research on objective and subjective characteristics of knitted structures with different composition and structure. The main goal of this study was to analyze samples of knitted fabrics that are made from yarns with different composition and structure. In order to fulfill the main goal, a total of twelve samples of knitted fabrics in three different structures and four yarn compositions were made.

The main tasks set out in the study were conducting a series of tests to determine objective and subjective characteristics that are inherent to both the samples and the subsequent final products. The objective characteristics were examined in laboratories of the Textile Technology Department of TU-Sofia, as the following tests took place:

- determination of the structural, geometric and mass characteristics of the twelve knitted samples;
- measurement and assessment of the operational characteristics assessing the quality of knitted fabrics;

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- determination of the thickness of the structure and the degree of compression under pressure;
- determination of the deformation behavior under tension, which also includes visualisation of changes in the structural characteristics of the knitwear;
- determination of moisture transport properties, respectively moisture comfort;
- determination of pilling;
- determination of the coefficient of static and dynamic friction;
- determination of thermal characteristics of the samples.

To determine the thermal characteristics of the knitted structures, surface temperature measurements were performed, conditions were created to isolate some of the environmental factors, and thus a significant rate of heat exchange between different materials and a user who could wear them as a garment or accessory was established within a short period of time. The measurement was made with a Flir C3 thermal camera (Fig. 5).

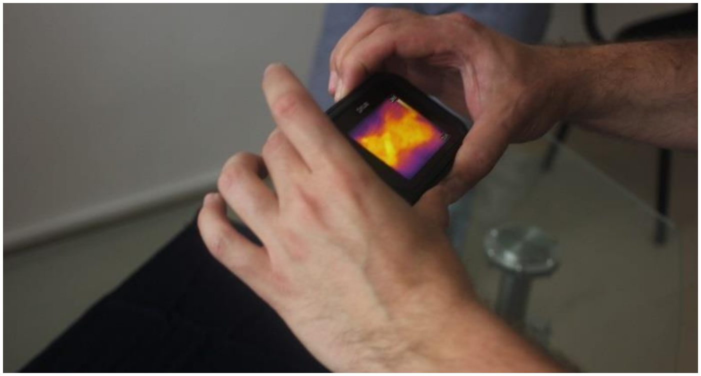


Fig. 5. Temperature measurement and general view of the FLIR C3 thermal camera

Thermal camera images of the knitted structures are shown in Figure 6. The images were taken after placing each of the fabric samples in contact with the skin of a user for 5 seconds. The temperature in the room was maintained constant for the entire period of the thermal camera shooting. Each photo depicts the thermal footprint of the samples. The temperature gradient of each knitted sample after contact with the user's skin is clearly provided.

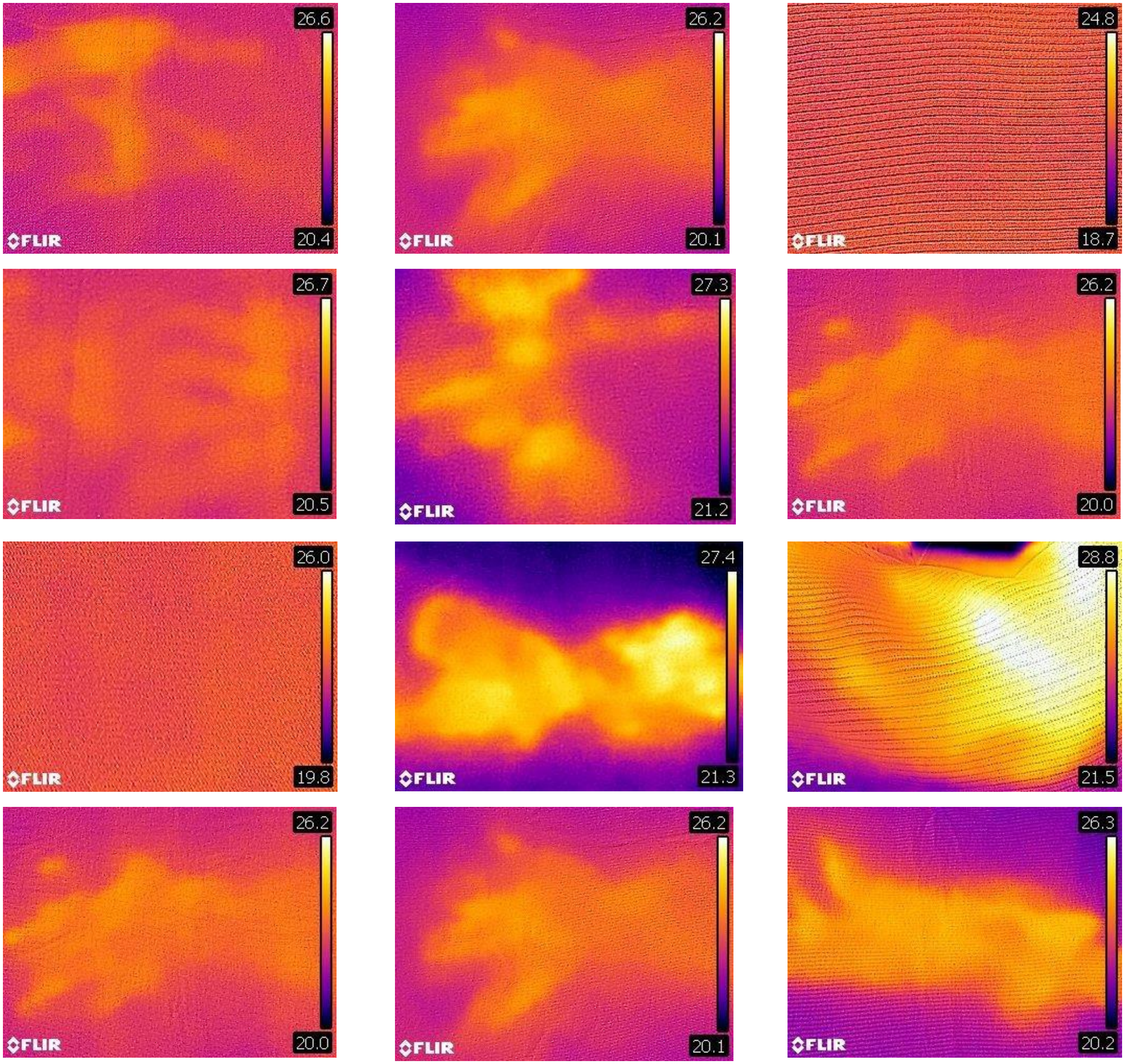

Fig. 6. Thermal images of the twelve knitted samples

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In parallel to the above, subjective characteristics were studied using sociometric methods among students and lecturers from Engineering Design Department of TU-Sofia. A survey was compiled for recording subjective characteristics with the individual stages of the experiment and various aspects of the behavior of knitted structures.

In the final stage of the experiments, a series of creative interpretations of temperature visualisations we developed in the form of art compositions that can serve as the basis for fabrics patterns. Some of photos used in the final art stage of the project, in which visual interpretations were created are shown in Fig. 7.

Fig. 7. Art visualisations of knitted structures

CONCLUSION

The results obtained after a series of tests and surveys and the analysis in the study gave answers for: 1. selecting optimal composition and structure with the aim of obtaining a product with the function of both clothing and an accessory; 2. producing of an industrial product that increases the comfort of wearing knitted products and the consumer experience; 3. refining and optimizing the construction and design of the final products; 4. using the material preferred by consumers and 5. creating new experimental knitted structures, with different fabrics patterns for industrial products.

Visualisations trough knitted structures can be used for wall panels, wallpapers, furniture upholstery, fabric patterns. Knitted structures presenting visualised information can be used in architecture, interior, exterior and fashion design, developing into art installations, decorations, home accessories and entire knitted clothing collections. The use of knitted structures to visualise various scientific data i.e. physicalization is an easy and affordable method that allows subsequent recycling. It gives new applications to knitting in scientific and applied fields that are far from the textile industry.

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Fig. 5÷6 – photo archive of the authors

Fig. 7 – photo archive of the authors and https://mrmockup.com/