Applications of Optically Actuated Haptic Elements

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Abstract. There are missing commercially available large area dynamic tactile displays providing access to high-resolution graphic and Braille for the blind people. This is not solved by currently available displays in the form of a Braille line. The objective of the project NOMS (Nano-Optical Mechanical Systems) is to solve this problem by using optically activated haptic actuators. These will require no hard to assembly moving mechanical parts and have the potential for finer resolution. Recently developed carbon nanotube enriched photoactive polymers provided the starting technology for this purpose. There will be presented development of materials of this kind and their integration into tactile displays.

Keywords: Braille, display, tactile, haptic, photo actuation.

1 Introduction

Most of the information is presented in visual form which is inaccessible to blind people. To make it accessible the synthetic speech and tactile displays are used. Tactile displays are the most suitable means to present exact writ-ten form and layout of a text and perhaps the only possibility to present graphics to blind people. Unfortunately, there are still missing commercially available large area refreshable tactile displays providing access to high-resolution graphic and larger blocks of Braille texts. Blind readers, as well as sighted people, need possibility to backtrack and review Braille text larger than one line and to review information units that takes more than one line like equations or tables. Even more serious problem is access to tactile graphics like maps, plans, diagrams, and schemes in real time. This problem is not solved by currently available displays in the form of a Braille line. Tactile graphics is obviously available in various forms of a relief print, which are not at disposal in real time; production process is complex, long and obviously not automatic. Exceptional special devices presenting graphics part-by-part on small refreshable tactile areas of fingertip size need hard training, excellent manual skills, good imagination and memory and therefore also do not represent satisfactory solution. Finally, more recently there occurred two-dimensional refreshable tactile graphical displays [1-2] based on the same principle as Braille displays using piezo electric elements. Although working very nice they are still extremely expensive not only for individual users, but even for institutions providing education and other services to the blind people. Thus, the current tactile technology for the blind people significantly limits their access to information,

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in particular graphics and more complex texts, needed for education, work, and everyday life in rapidly developing information society. Therefore revolutionary technologies are needed to improve the lives of blind people providing better access to information.

The project NOMS - Nano-Optical Mechanical Systems [3] offers one promising solution - the use of actuators that can be activated optically, using materials changing their size by influence of light. These require no bulky moving parts and have the potential for much finer resolution than current technology. The most challenging task of the project is research and development of suitable optically active materials [4-6]. Recently developed carbon nanotube enriched photoactive polymers have provided the starting technology for this purpose. Liquid Crystal Elastomers (LCE) and also other polymers are examined.

2 NOMS: Objectives

The main objective of NOMS project is research and development of proto-type of photo-actuated large area, high resolution, and fast refreshable, tactile display - tablet - working as follows:

- The original video signal from a computer screen will be transformed into pulses that will trigger the appropriate emitters in the tablet.
- The light emitted by LED/LD-like platform will be focused by microlenses on a polymer NANO-composite film
- The photo-actuation of the film will be tailored to enable tactile graphic representation.
- The final tablet will have the following features:
- 80x80 blisters tactile display with 1.25 mm mutual distance
- Full text and graphical capability
- Tactile distances below human touch resolution enabling more smooth tactile graphics
- Rapid refresh rate. The estimated actuation speed of one blister is 100 ms, which will yield a maximum reaction delay for changing the whole display contents of a 100x100 mm display of approximately 1 second, assuming sequential actuation.
- Easy modular integration for larger display capability (A4 format by 6 modules)
- Fully integrated electronic circuitry
- Wireless Capability to connect to a PC and other devices
- Portability

Photomechanical actuation is preferred to electromechanical transduction also due to following technical and safety reasons:

- Wireless actuation
- Electrical-mechanical decoupling
- Low noise
- Easy scaling up/down

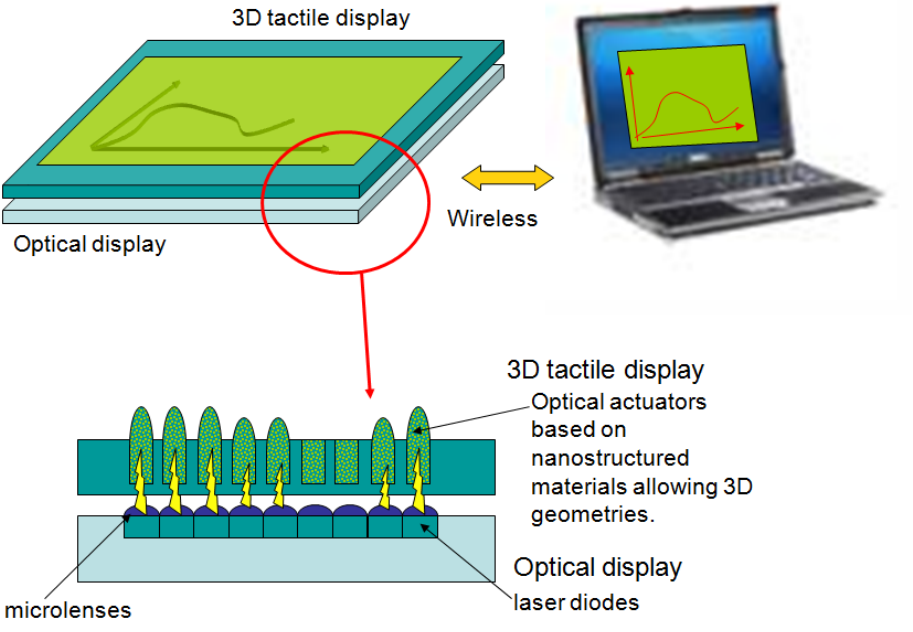

Fig. 1. Schematic of proposed visual-aid NOMS, showing computer wireless interface along with subjacent optical technology (source: Project NOMS)

3 The Work Performed So Far

The work covers the research and production of photoactive NANO-materials, blister and tablet design, communications and control software, optics and microsystem integration, as well as end user evaluation and neuro-cognitive studies.

A very important task has been the research and choice of actuating material [4]. However, only few materials actually exhibit photo-actuation. Initially, we favored carbon nanotube-polymer composites because of expected decreased manufacturing costs and true photo-actuation. But better results were found for liquid crystals elastomers. Actuation parameters (magnitude of the stroke, needed exerted force in tactile applications, etc.) in liquid crystal elastomer (LCE) materials have outperformed those of carbon nanotube polymer systems. Also, one of the initial disadvantages of the LCE materials, their transparency to visible light, has been overcome by incorporating carbon nanotubes in the elastomer to produce absorption over the complete visible spectrum, allowing successful actuation of LCE-CNT material using a visible LED light source. Nevertheless, we are not fully satisfied with some characteristics and stability of those materials needed for construction of haptic displays. Therefore the material research continues. At present we work with materials doped by laser welding dyes which seem to be more promising.

The work continues on an intermediate deliverable, a prototype of 10x10 tactile tablet with a pitch of 2.5 mm to allow standard Braille representation using different photo-actuated materials.

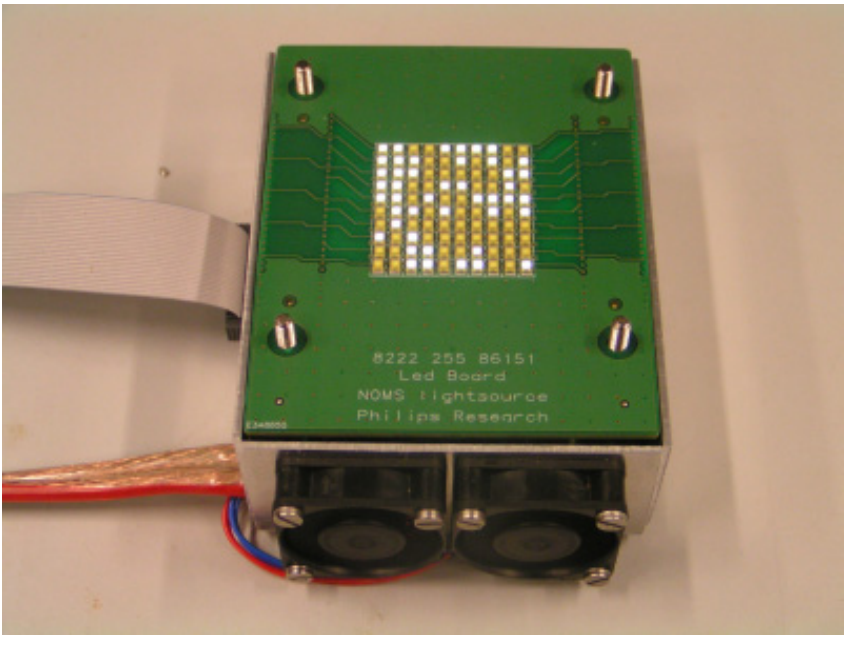

Fig. 2. 10x10 light emitting layer and driver boards (the LEDs are lit by random data). (source: Project NOMS)

The interface between the PC and the NOMS tablet has required development of software to perform the visual to tactile transformation, Wireless communication to transmit the tactile image to the display, to control electronics to operate the tablet. A first version of the software has been re-leased and the wireless communication protocol has been chosen.

4 Potential Impacts and Use of Final Results

Knowledge gained by studying photo-active NANO materials during NOMS project development will open new horizons for practical as well as research purposes not only for blind people, but for general public as a means of design for all.

The NOMS graphical display will be for instance suitable for use as a novel research tool for neuropsychologists allowing major progress in this field which has so far been limited by existing tactile technology which is either non-refreshable (e.g. embossed on paper) or just new very expensive devices [1-2] with lower resolution than proposed by the NOMS project.

Another hopeful application is a single tactile element resembling LED. It might be used for the same signaling purposes as LED, parallel with it or instead of it. This technology could be applied for signaling purposes (power on/off, recording on/off, heating on/off, waiting message etc.) to support or substitute visual perception.

The work proposed here identifies a new direction leading to Implementation of NOMS technology in non-assistive applications which will also be of great interest to the general public judging by the advent of multiple tactile interfaces in PDAs, cell phones, music players and large surface personal computers. Research of photo active NANO-materials will support also development in multiple adjacent fields such as medicine or robotics through artificial muscle technology.

5 Conclusion

The proposed device will comprise an invaluable added advantage over current assistive technology by provision of graphic and text information on a large area fast refreshable tactile display. Moreover NOMS is addressing also other specific needs of visually impaired people since that technology is readily adaptable to the latest and most common technical developments like e-books, i-phones and all featuring flat screens without classic key-boards. It could really improve accessibility of electronic information every-where. The results of the material research will also provide significant contribution to nano-technologies in general.

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