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EPIDERMAL SYSTEMS AND VIRTUAL REALITY: EMERGING DISRUPTIVE TECHNOLOGY FOR MILITARY APPLICATIONS

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ABSTRACT
This work analyzes at what extent invisibility is possible by emulating nature, and if military applications can benefit from technology that combines epidermal systems and virtual reality.

INTRODUCTION
Camouflage and mimicry and have a long-standing tradition in military applications from the 19th century (Forbes, 2009), but eventually have proved to have a limited effectiveness (Scott-Samuel, 2011). In more recent times, has been introduced a multi-scale camouflage that combines patterns at two or more scales, often with a digital camouflage pattern created with computer assistance (Billock, 2010). This function, that is called "scale-invariant camouflage" or called fractal camouflage, does not of itself guarantee improved performance.

ADAPTIVE CAMOUFLAGE
The skin is a relatively underexplored sensory interface that could significantly enhance experiences. The research focuses on the fundamental and applied aspects of silicon nanomembranes, ranging from synthesis and manipulation to manufacturing, device integration and system level applications, including uses in bio-integrated electronics, three-dimensional integrated photonics, solar cells, and transient electronics (Rogers, 2016).
Material scientists have developed a color-changing sheet inspired by squid and octopus, whose skin can transform to blend with its surroundings (Yu, 2014). The basic idea is that the creatures use light-sensitive molecules in the skin to register the light coming from the background against which they sit, and then use this information to alter the appearance of colour-changing cells.
To make the adaptive displays, the researchers began by imprinting a 16x16 grid of cells on a soft plastic. The cells, each about a millimetre across, contain a colour-changing dye embedded in a polymer. The dye is black at room temperature, but when warmed to around 47°C (117°F) its chemical structure changes and it becomes transparent. Cool it, and it becomes black again. At the corners of each cell the researchers added tiny light sensors that record how much light falls on the cell, and this signal is used to control an electric current that helps warm up the dye. Shine a light on the material, and the black dye will turn transparent and expose a reflective silvery material beneath.
A fabric coated with miniaturised Light Emitting Diodes (LEDs) and cameras that, by projecting the appropriate background image in all directions, could confer genuine invisibility.

EPIDERMAL VIRTUAL REALITY
A thin, wireless and battery-free system adds a sense of touch to any virtual reality (VR) experience (Yu, 2019). It is a platform of electronic systems and haptic interfaces capable of softly laminating onto the curved surfaces of the

skin to communicate information via spatio-temporally programmable patterns of localized mechanical vibrations. Referred to as an "epidermal VR" system, this equipment communicates touch through a fast, programmable array of individually programmable, millimeter-scale actuators, fused in skin-interfaced wearable scalable device, with almost no encumbrances on the user.
Each actuator — currently they have diameters of 18 millimeters and thicknesses of 2.5 millimeters — resonates most strongly at 200 cycles per second, where the skin exhibits maximum sensitivity. The frequency and amplitude of each actuator can be adjusted quickly and on-the-fly through a graphical user interface, to maximize the sensory perception of the vibratory force delivered to the skin. The patch wirelessly connects to a touchscreen interface. When a user touches the touchscreen, the devices produce a sensory pattern, simultaneously and in real-time, through the vibratory interface to the skin.
This emerging disruptive technology could be combined with a VR headset. Eventually, the devices could be thin and flexible enough to be woven into clothes. And along with VR headsets, people could wear suits to become fully immersed into VR. The result is a thin, lightweight system that can be worn and used without constraint, indefinitely.

RESULTS AND CONCLUSIONS

This study shows that, to be effective, camouflage needs to match the environment and to be disruptive. Military applications can benefit greatly from adaptive and epidermal VR.

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