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CURVACE – CURVed Artificial Compound Eyes

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Abstract

CURVACE aims at designing, developing, and assessing CURVed Artificial Compound Eyes, a radically novel family of vision systems. This innovative approach will provide more efficient visual abilities for embedded applications that require motion analysis in low-power and small packages. Compared to conventional cameras, artificial compound eyes will offer a much larger field of view with negligible distortion and exceptionally high temporal resolution in smaller size and weight that will fit the requirements of a wide range of applications.

Keywords: Artificial vision; compound eyes; bio-inspired engineering; vision-based navigation

1. Introduction

The vertebrate eye has provided inspiration for the design of conventional cameras to provide a faithful rendering of the visual world for a large variety of uses like object recognition. However, such vision systems require too complex computation when the extraction of motion-related information is pursued. The insect compound eye, instead, consists of a curved array of individual vision units, called ommatidia, composed of a microlens that conveys light to a separate set of photoreceptors. Despite their lower spatial resolution, it is very efficient for motion analysis over a large field of view (FOV), making it an excellent sensor for accurate and fast navigation in 3D dynamic environments. Compound eyes take several shapes and curvatures to fit the head and viewing directions of very different types of insects while offering the same functionality. Curved vision systems inspired on compound eyes have recently raised the interest of the scientific community. However, their design still presents several technological and scientific challenges since the most common approach drastically departs from the design of conventional cameras.

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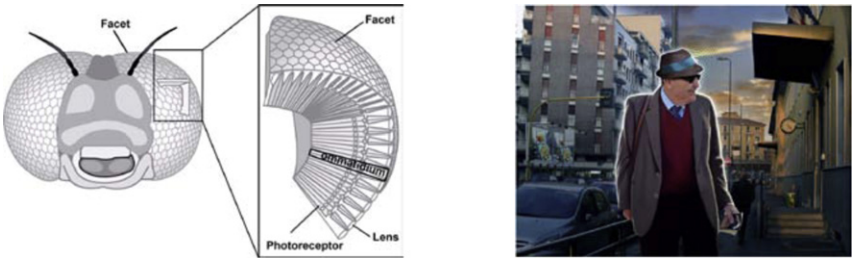

Figure 1. Scheme of the compound eye of an insect (left), and visionary image of a CURVACE device as wearable collision-alert system for visually impaired people.

2. Project Overview

CURVACE aims at designing and prototyping CURVed Artificial Compound Eyes [1]. These novel vision sensors will be composed of microlens arrays integrated with adaptive photoreceptors made of analog Very-Large-Scale-Integration (aVLSI) circuits on flexible electronic substrates. The output of the artificial compound eyes will be processed by vision filters for fast extraction of motion-related information implemented in embedded programmable devices. Compared to conventional cameras, CURVACE will offer much larger field-of-view, very high frame rate and unparalleled sensitivity in smaller, lighter and thinner package. The project will open new ways in artificial vision sensing introducing curved and flexible imagers with fixed or undefined shape. Bio-inspired principles of active vision will be explored by applying specific micro-movements to imagers that will greatly increase visual acuity. As well, novel visual filters that self-adapt to the changing curvatures of the compound eyes will be developed. Furthermore, the readout electronics will be designed so that they are compatible with other types of processing devices, such as neuromorphic chips, which could be directly interfaced to the aVLSI adaptive imagers at the place of the programmable device (Figure 1).

CURVACE will provide advantages and novel functionalities in several application scenarios, such as flying micro-robots, wearable sensing, miniature collision-alert systems, medical endoscopes or soft robots, where motion-related processing, wide field of view, and small skin-like packaging are important.

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Reference

[1] http://www.curvace.org.