УДК 629.05

V.A. Antonenko, Professor V.M. Borovytsky
NTUU "Igor Sikorsky KPI"

CLASSIFICATION OF KNOWN BIOLOGICALLY-INSPIRED VISION SYSTEMS

Annotation. Considered all existing facet-similar vision systems. All the advantages and disadvantages of such systems are presented and described. The proposed model of biologically-inspired system is given.
Key words: Facet eye, vision system, navigation, prototypes, UAV.

INTRODUCTION

Nowadays, almost every aerial and ground vehicles have various auxiliary systems that provide the definition of such parameters as orientation in space, velocity, tracking of further direction, obtaining obstacles, etc. GPS technology is one of them. The main disadvantage of this system is that the signal from transmitter in some cases cannot be received by device or it can contain low accuracy because of noises. Another example is an event camera that can be used for navigation and recognition with help of technic vision. However, this solution has low speed of computation in cases that requires fast decision-making. On this basis, there is a need to look on nature-based vision models that have interesting features. We decide to consider compound eyes of insects. It is known that flying arthropods with help of their facet-similar eyes can detect and further avoid obstacles with high reaction speed. In addition, a large field of view allows them to observe almost all around environment space. For the reasons given above, there is necessary to implement classification of all existing analogues.

To achieve a large field of view engineers creates monocentric, large-scale camera AWARE-2 that includes an array of cameras on hemispherical surface (Fig. 1) [1].

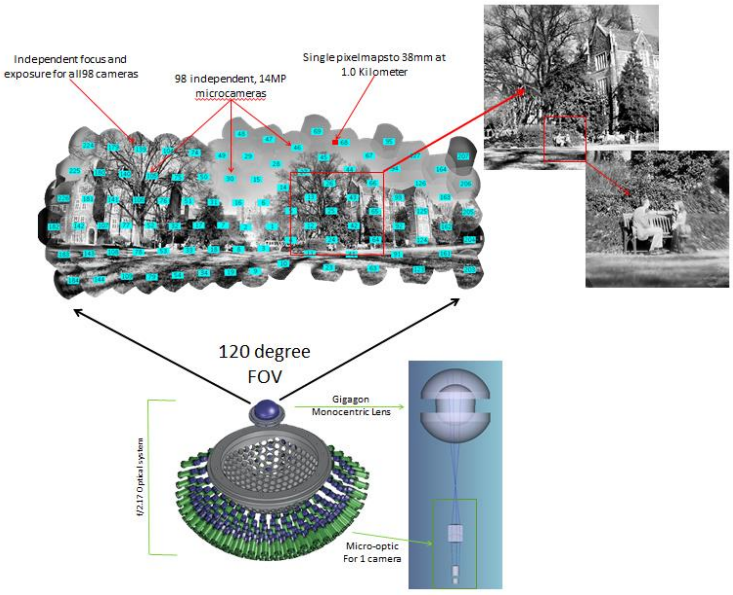

Figure 1. Monocentric camera AWARE-2

The spatial resolution of such camera is up to one gigapixel with viewing angle of 120° to 50°.

This system allows us to create an image in size of one gigapixel at a viewing angle of 120° to 50°. Main disadvantage is the transferring of large amount of information in real time via an electronic channel, further processing and recording [2].

The use of multi-chamber optoelectronic systems with a specific form of optical components in one device also increases the cost of the entire device.

Another solution of biologically-inspired vision system is the development of an artificial compound eye, called CurvACE (Fig. 2) [3, 4]. The angle of view of such a prototype is 180° to 60°.

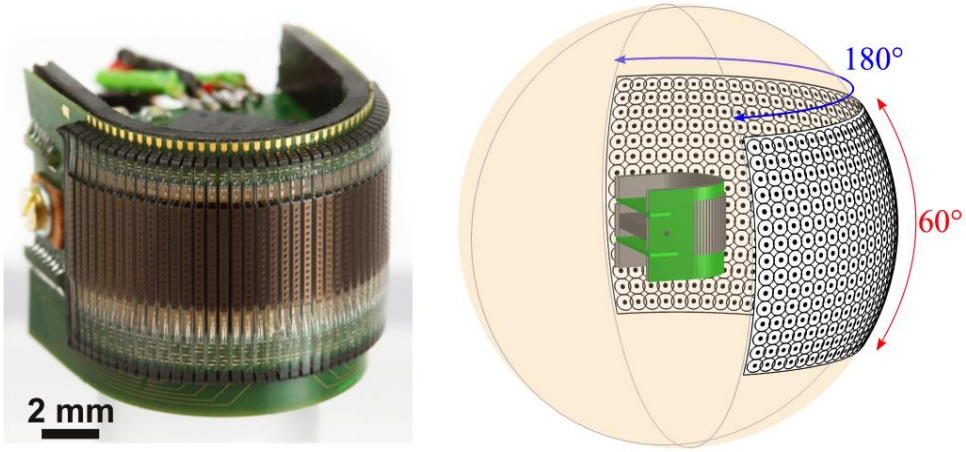

Figure 2. Artificial compound eye CurvACE

As in the biological compound eye, CurvACE contains three material and functional layers (Fig. 3).

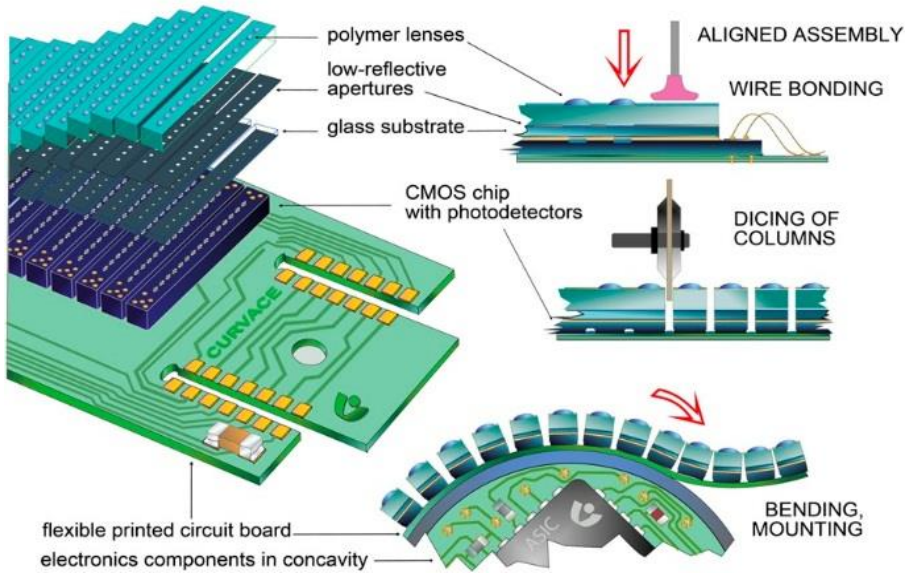

Figure 3. Design of artificial eye CurvACE

The first layer contain array of polymeric microlenses molded on a glass carrier, which focus light onto second layer that includes silicon-based photodetectors array. Last layer is a flexible electromechanical board that transmits output signals to processor units. The use of a single microprocessor in such a solution may not be sufficient since a high speed of signal processing from each photodetector is required.

The third example most similar to structure of arthropod eye (Fig. 4) [5]. It contains a two main subsystems. The first one is an array of molded convex microlenses with radius of curvature r ≈ 400 μm. The second subsystem enables

photodetection and electrical readout. It consist an array of thin silicon radiation sensors and blocking diodes. Each photosensor placed in focal position of corresponding lens.

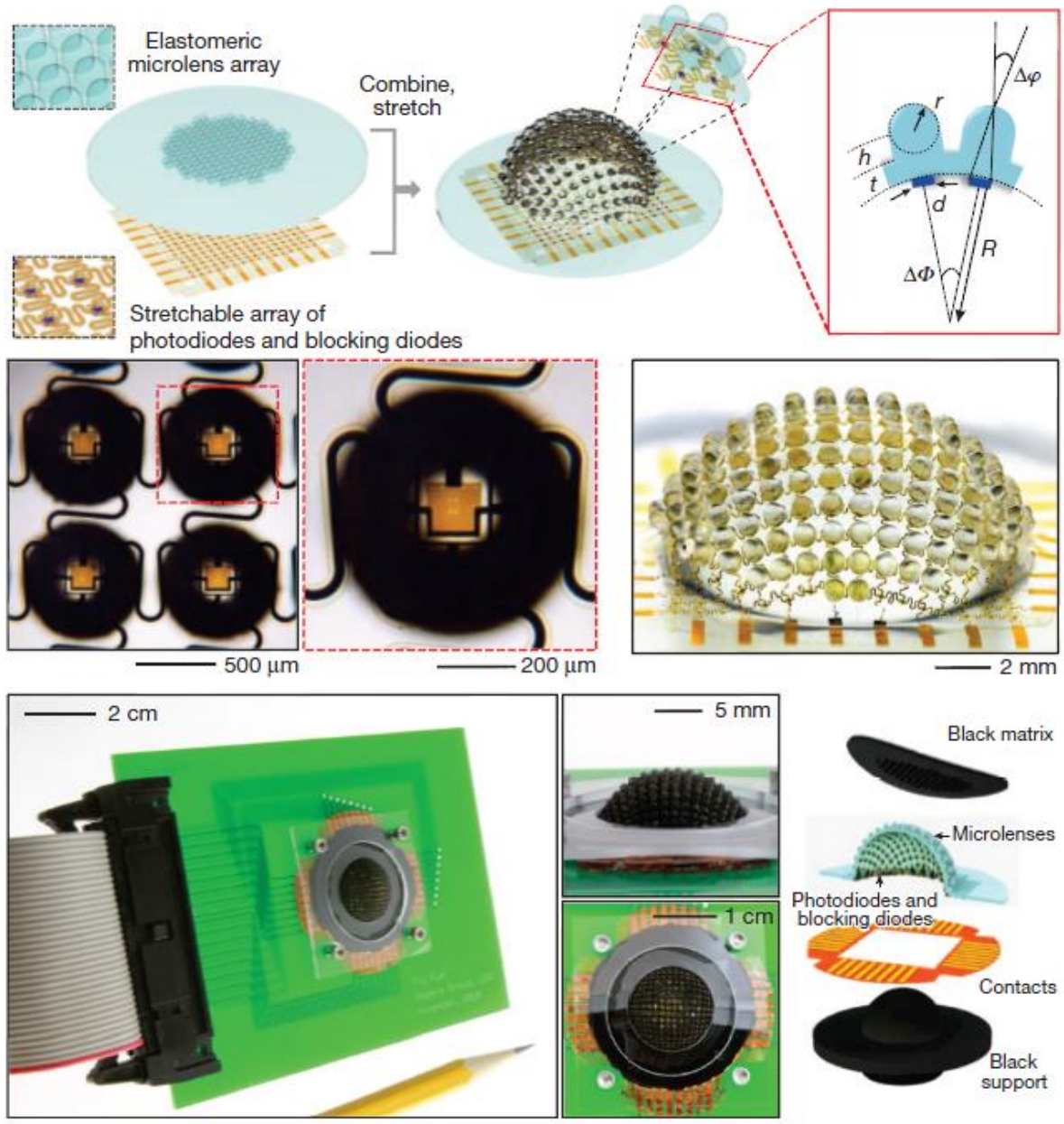

Figure 4. Biologically inspired vision systems based on digital cameras

By analogy to imaging organs in arthropod each microlens and supporting post corresponds to a corneal lens and crystalline cone, respectively. Each photodiode is a rhabdom. A collected set of each of these elements represent an ommatidium.

We propose the design of a biologically-inspired vision system that is contain a number of optical systems with a set of photodectors and parallel signal processing units (Fig. 5).

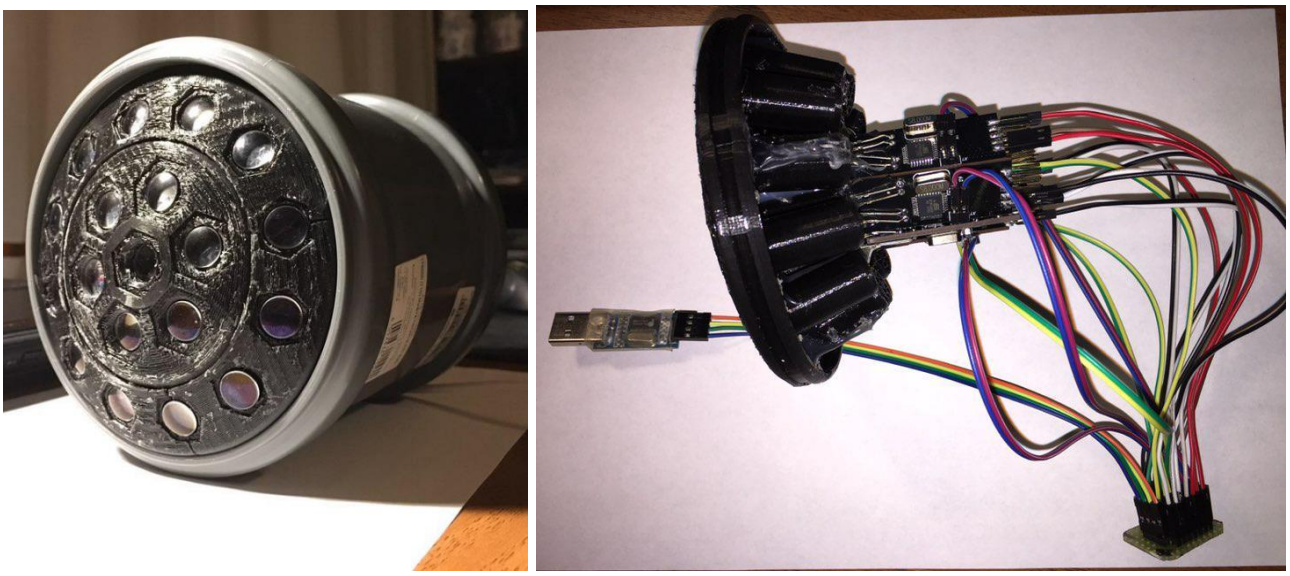

Figure 5. Prototype of biologically inspired vision system

CONCLUSIONS

Summing up it is needed to say that using of facet-similar models is a great solution for creation of modern vision systems. Parallel preprocessing in such devices can improve efficiency of entire system that is allow to reduce amount of collision and accidents. It is very important in vehicle or UAVs control.

REFERENCES .

[1] Marks D.L. Engineering a gigapixel monocentric multiscale camera. D.L. Marks, H.S. Son, J. Kim, D.J. Brady // Journal Optical Engineering / Duke University. – 2012. – Vol. 51. – 14 P.

[2] Antonenko V. Features and cost comparison of biologically inspired vision systems V. Antonenko, V. Borovytsky / Conference Works // NTUU “Igor Sikorsky KPI”. – 2018. – 49 P.

[3] Floreano D. Miniature curved artificial compound eyes D. Floreano, R. Pericet-Camara, S. Viollet / Scientific Journal PNAS // Laboratory of Intelligent Systems, École Polytechnique Fédérale de Lausanne. – 2013. – Vol. 110, №23. – 6 P.

[4] EP 2 306 230 A1, J. Duparré, A. Brückner, F. Wippermann, Jean-Christophe Zufferey, D. Floreano, N. Franceschini, S. Viollet, F. Ruffier, Artificial compound eye and method for fabrication thereof, April 6, 2011.

[5] Young Min Song Digital cameras with designs inspired by the arthropod eye Young Min Song, Yizhu Xie, Viktor Malyarchuk // Nature. – 2013. – Vol. 497. – 99 P.

Наук. керівник – д.т.н., професор Боровицький В.М.