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Table 20.

Comparative assessment of trend definition

Criteria	Measured sample	Trend time (measurement)	Recognition quality (%)	The quality of trend recognition when changing		
				σ_y (%)	α (%)	τ_0 (sensitivity)
Classic	50	7-8	95	70-95	60-95	10-25 (measurements)
Neural networks	50	4-5	100	95-100	95-100	3-5 (measurements)

At present, when solving complex complex tasks of information monitoring and operation of engines, complex ensemble NM can be successfully used, which, in comparison with conventional fully-connected NM, can provide additional advantages in practice: decomposition of a complex dynamic object (its systems) into a number simple objects (subsystems); On easier to adapt to changing external conditions (in the class of adaptive, self-tuning systems); NA structure can be optimized for a specific task; the speed and accuracy of the NA are significantly higher than the classic fully-connected NM;

HA provide a better approximation of piecewise continuous functions.

The above advantages of NA over conventional fully-connected NM give the possibility of their further application in solving problems of information monitoring, operation management and design of electric motors.

9.2 Applying of hexagonal raster in image formation

Introduction

Today researchers pay attention to the advantages of the hexagonal raster by formation and representation of an image more often [192-193]. These benefits allow to increase the realism of graphical images forming in many cases [193]. Advantages stem from hexagon`s ability to cover screen surface without gaps and overlays and

also hexagon`s geometrical specialties, like reflection symmetry and coherence of hexagonal raster.

Scope of application of hexagonal raster in visualisation systems

One of the first digital cameras with the matrix, that was made using hexagonal pixels, was released by Fuji Photo Film in 1999 [4]. This matrix was called Super CCD Honeycomb and created in order to expand the total area of photodiodes on the matrix, that allows to increase sensitivity and enlarge the range of photosensors. Pixels in Fuji`s photosensor were rectangular-shaped and were placed next to each other [194]. Pixels in Super CCD Honeycomb are hexagonal-shaped. Due to such topology the area of the matrix is used with higher efficiency, there`s more light captured for each surface unit and that`s why dynamic range is reflected wider. Sensors with hexagonal elements give better results on horizontal and vertical scanning, which a human eye is most sensitive to.

Paired photodiodes are also applied into Super CCD Honeycomb construction, they are located as double cells, that`s why matrix can operate with any particular light intensity [3]. First photodiode from a double cell is configured for high photosensitivity, the other one is for lower light, it allows to take pictures in any light condition (pic. 63).

Microlenses, that are made as a hexagonal array, are used in the manufacture of optical gears. In particular, such arrays of the microlenses are applied in the Airyscan detector in the laser scanning microscope ZEISS LSM 800 [195].

The operation principle of Airyscan`s electric scheme is that a hexagonal array of microlenses is connected directly to the ends of the fibre bundles and captures falling light[4]. On the other end the fibre is in contact with the linear array, that functions as a detector.

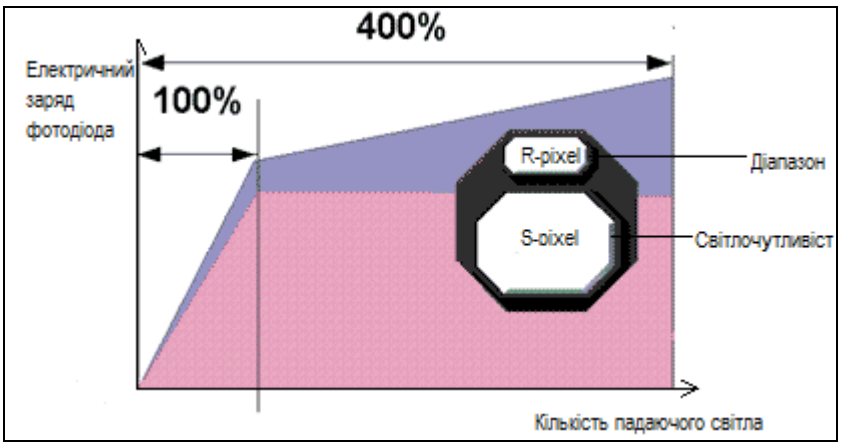
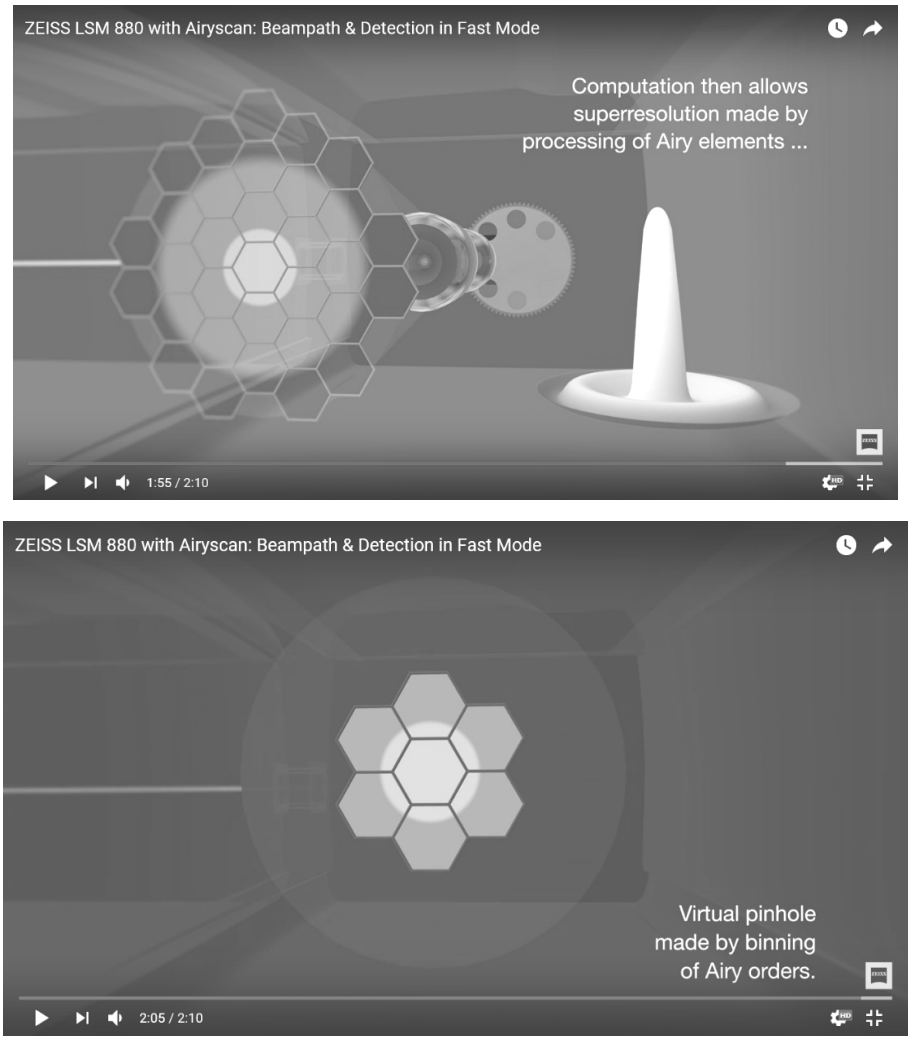


Рис. 63. Double hexagonal pixel

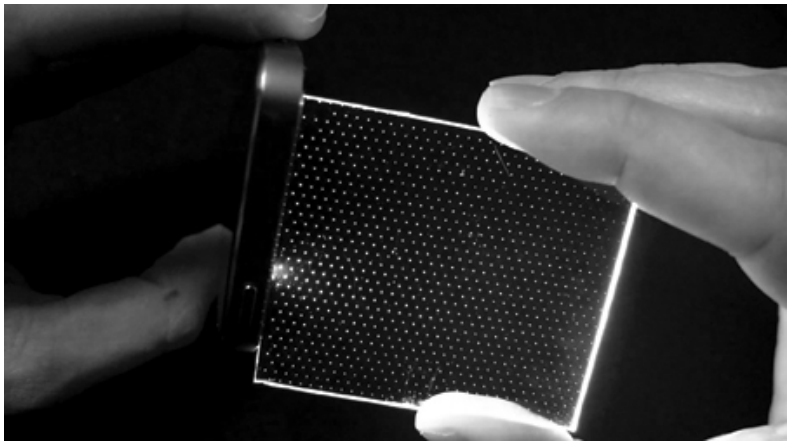
Thus, a picture is configurated with the help of optical scaling to Airy disc. Meanwhile, single element of the detector acts as a separate microaperture in the detector (Pic.64).



Pic. 64. Hexagonal array of microlenses of Airyscan detector

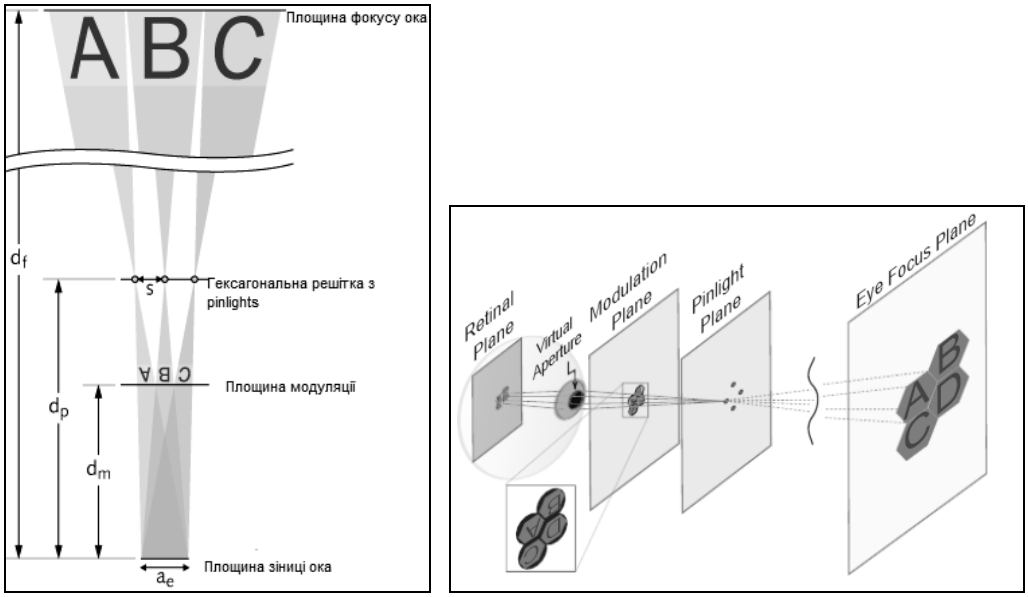
In VR glasses from Google (Google Glass) [196], each eye has its own ‘pinlight’ array, that consists of white light – highlighting cones of the transparent acryl layer and low deepening hexagonal grid cells. Hexagonal cells capture full inner light reflection and create so-called point light. The operation principle of them is the same as in camera obscura (Latin), that can capture an image without an objective [196].

Hexagonal array eliminates a need in focusing optics, except user`s pupil of the eye (pic.65).



Pic.65. Google Glass display

Light from hexagonal LCD grid with pinlights is being designed using spatial light moderator (SLM) in order to get full picture on the retina (Pic. 66).

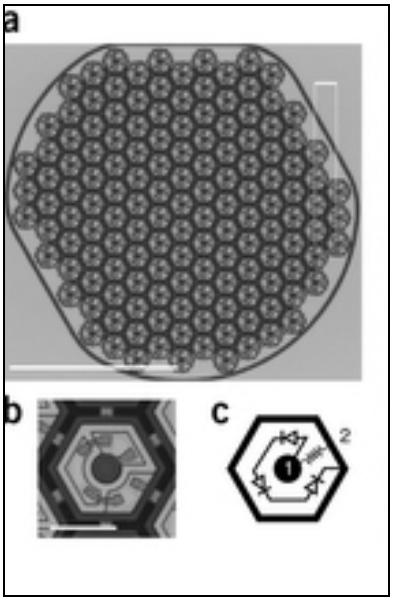


Pic. 66. Hexagonal array Pinlight

Hexagonal arrays are made separately for each eye and installed on the frame.

As a result glasses are light and suitable for constant wearing in Google Glass VR displays [196].

Photovoltaic prosthetics are used for prosthodontics of patients with retina degeneration, whose eyesight is lost because of progressive photoreceptors breakdown. Electrical stimulation and neurons implementation of retina provides an alternative way for delivery of visual information (pic. 67).



Pic. 67. Zoomed image of photovoltaic prosthetic module

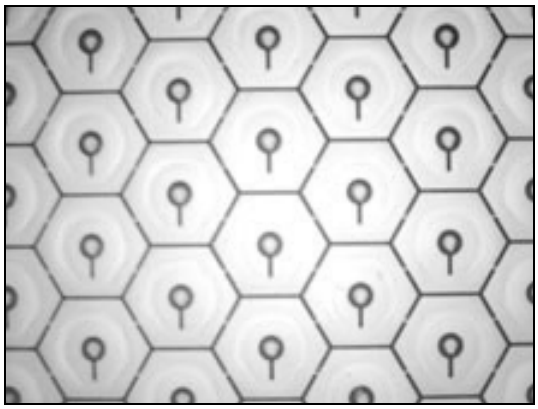
The module of the photovoltaic prosthetic consists of hexagonal pixels, that are 70 μm wide [197].

Easy implantation of these hexagonal wireless and modular arrays, combined with its high resolution, gives an opportunity to regenerate the eyesight of the patients, who have lost it because of the retina degeneration [197].

Creation of electronic devices, that form an image in reflected, but not in radiated light, originally, started in the `70s last century. Biggest advantages of such ways of image outputting are picture naturalness for a human`s eye, a wide angle of sight and a low energy consumption. Flexibility, strength and a small weight are also

innovative mechanical benefits of displays. Such displays and complex of its creating technologies are combined into the common name ‘E-paper’ [198].

E-paper display matrix contains hexagonal pixels (hexagonal-shaped cells) [198]. There is a tank with a black paint in the middle of each hexagonal pixel and this paint is spread through a thin channel all over the pixel (under the influence of voltage) (pic. 68).



Pic. 68. E-paper display matrix

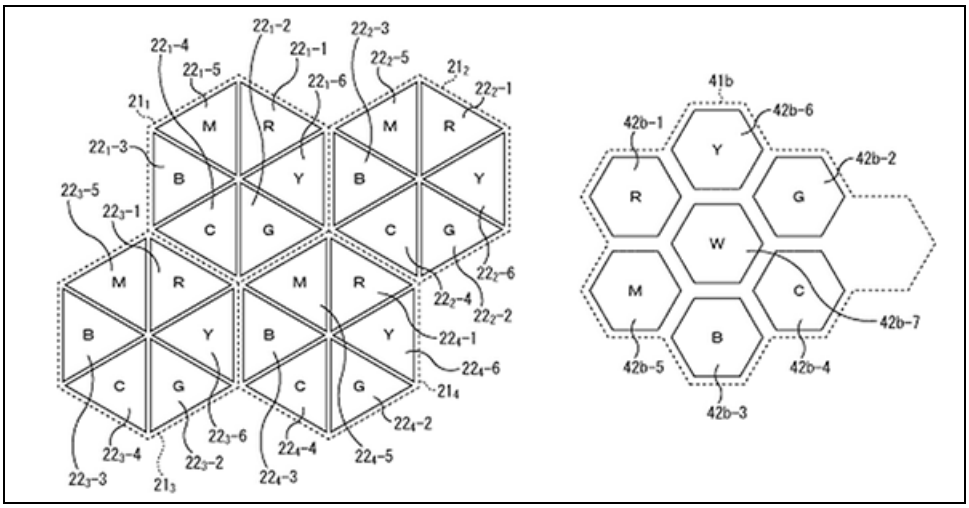
A thin aluminium layer functionates as a reflecting basis and a coal ink is used as a black paint. Aluminium is applied on a polymeric surface and covered with Indium Oxide and Tin Oxide, that`s how a transparent electrode is made. Under the voltage the ink is getting squeezed out and spread out because of electromechanical pressure. When voltage is turned off, the ink drains back into tank due to the curvature of the channel and physical shape of hexagonal pixels [198].

The pixels shape is 100 μm wide, it allows to make screens with the resolution up to 300 pixels/inch. This pixels size provides flexible screens creating .

Time transition between white and black colour of the pixel takes 1 millisecond, it is enough for playing a video. The background brightness depends on the amount of reflected light, the screen material in E-paper reflects 55% of any light, that falls onto it (for instance, a white paper reflects 85%) [198].

It is intended to turn white-black E-paper technology into full colour one. Hexagonal pixels, that are used in the white-black technology, is the most suitable solution, they can be separated and filled with red, green and blue colours.

SONY patented a technology of hexagonal pixels matrix development [199], where each pixel consists of a hexagonal elements set, that simulates its own colour (pic. 69).



Pic. 69. Variants of colour topology in hexagonal pixels SONY

Advantage of this technology is a combination of CMY and RGB filters, that considerably increases the characteristics of filter`s spectral sensitivity. This combination can improve colour representation in order to process the images successfully. CMY filter has higher capacity, than RGB filter, that's why it`s more 'saturated', regardless of the technical realisation [199].

The undeniable benefits of technology suggested by SONY is the image quality and portability of the devices with hexagonal matrix.

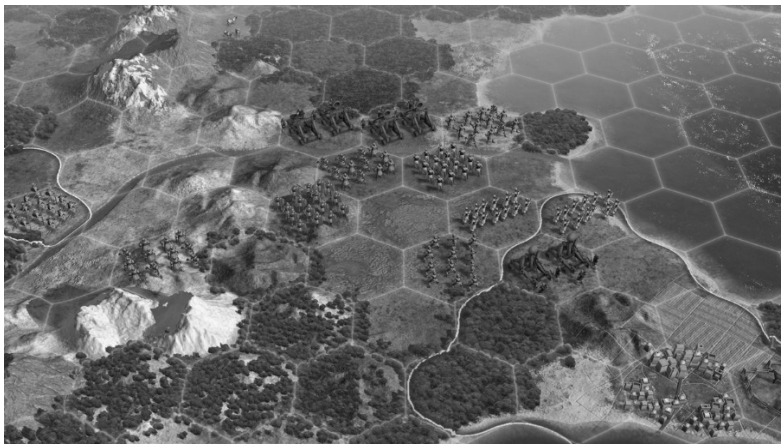
Implementation of hexagonal elements gains momentum in computer and tablet games.

The most famous and popular game for its time, Heroes of Might and Magic 3 used hexagonal topology of the playing map. The playing field was separated not

into squares, but into hexagons [200]. It gave an opportunity to move a character in 6 directions and increasing the quantity (2 more) of interacting field sites (pic. 70).

Pic.70. Game map - Heroes of Might and Magic 3

The well known game, Civilization has released its 5th version on the hexagonal map too [201]. This way it became impossible to move onto diagonals of a square, for there were no squares actually. Now the movement in all 6 directions is balanced by distance. A new landscape generator, that is based on the hexagonal map element, was used in the game too. It also added tactical challenges to the gameplay. Also hexagonal space is perceived better (pic. 71).



Pic. 71. Game field in Civilisation 5

The popular strategic game with nuanced graphics, Endless Legend is designed on the hexagonal map too [202]. It improved perception and gave an opportunity not

just to apply hexagons, but to use the areas, that are constructed out of the hexagon-shaped fields. This approach provided detail and bigger quantity of interactive combinations (2 more, comparing with square), what is connected with hexagonal raster.

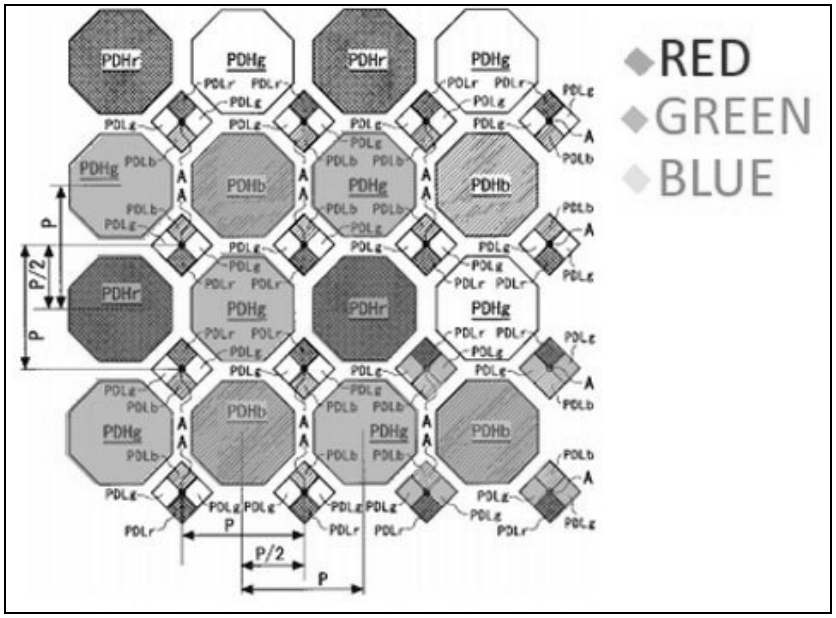
Today the great number of smartphone games in ‘strategy’ genre are constructed on the hexagonal game maps: UniWar – developer TBS Games, Catan – developer USM, Conquest! Medieval Realms – developer Slitherine, Eastern Front: Conflict-series – developer Joni Nuutinen.

Reflection symmetry inherent in the hexagonal raster and ability of equilateral hexagon to fill up the surface without any gaps and overlays allow to create the maps of small size, that suit to the screens of smartphones.

Samsung Company has developed a new pixel structure, that is used in new AMOLED technology, for its smartphones and tablets [203].

Implementation of the hexagonal and rhombus-shaped pixel structures allowed to develop 440 ppi screen resolution [203]

Nikon Company also goes this way, it has patented a cellular touchscreen with the subpixel in order to improve the dynamic range (pic. 72) [204].



Pic. 72. Nikon touchscreen with subpixel

Dynamic range improving is reached due to addition of 4 subpixels around the main pixel.

Conclusions

Given information demonstrates a wide spectre of use of hexagonal raster for image creating. It is believed, that screens, that are made on a hexagonal pixel basis, will be used in VR visualisation systems.

9.3 Intelligent implants in orthopedic surgery

Introduction

Intelligent implants can provide personalized medicine, optimize the care of individual patients, and improve results while reducing costs [205]. As diagnostic tools, smart implants can provide information that characterizes the environment inside the body that cannot be obtained in any other way. This information can provide objective quantitative data for adapting treatment, initiate changes in care, and detect adverse events at an early stage of treatment. Intelligent implants can also provide continuous monitoring of critical parameters for real-time processing. The integration of implants into daily clinical practice has the potential for large cost savings in the healthcare system by minimizing costly complications, shortening recovery time, and reducing lost working days after surgery and procedures. Implant-based intelligent research has also made an important contribution to understanding pathophysiology, healing, implant interfaces, and biomechanics. They also provide important knowledge for the development of next-generation implants and surgical techniques. Although the technology behind smart implants, including sounding, energy transfer, energy storage, and wireless, has advanced significantly in recent years, there are still significant technical challenges that must be overcome before implants become part of healthcare. In all applications, the intelligent implant - e is the vehicle that carries the diagnostic technology in the body. Due to the relatively large physical dimensions of many orthopedic implants, the bulk provides the