How are the visual percepts constructed?

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Abstract

How does visual system analyze the incoming visual information and reconstruct from it a (highly artistic) picture of the external world? I encountered this problem for the first time for about 35 years ago while listening some lecture about what happens in retina. Although I have written also about visual qualia and visual perception, I have not considered this particular problem. In TGD framework a rather simple model suggesting why and how visual perception first constructs a simple sketch analogous to cartoon about the visual field.

1 Introduction

How does visual system analyze the incoming visual information and reconstruct from it a (highly artistic) picture of the external world? I encountered this problem for the first time for about 35 years ago while listening some lecture about what happens in retina. I was working with my thesis as an unemployed in a job with the (hidden for me) purpose to make me capable of getting a job in a real world. The job itself was a purely formal duty and I was allowed to prepare my thesis rather freely (this would not be possible nowadays). I had also opportunity to listen lectures and this particular lecture series about neuroscience by Kari Kaila has teased me since then. Although I have written also about visual qualia and visual perception [K4, K3, K1, K2], I have not considered this particular problem.

In TGD framework a rather simple model suggesting why and how visual perception first constructs a simple sketch analogous to cartoon about the visual field with saccadic motion playing a key role in the process.

2 Basic facts

Let us first summarize the basic facts about visual perception that I learned for decades ago and have learned since then and somehow related to the challenge of understanding how the basic structure of visual percept might be constructed.

1. In the primary visual cortex there are so called orientation columns [J2] http://en.wikipedia.org/wiki/Orientation_column. The are geometrically flat slabs parallel to each other and orthogonal to the surface of the cortex being arranged like slices of bread. The neurons inside the columns are highly discriminatory for visual orientations and their motion. Wikipedia article also mentions pinwheels: orientation columns characterized by different orientation angles meet at singular points. This bring in mind radial lines emanating from origin and defining discretization of the azimutal angle.

   This sounded very strange to me. Why not divide visual field to small cycles or squares and be sensitive to the light in a particular square defining the bit?

2. I learned that there are also simple and complex cells. Simple cells are sensitive to a particular line. Complex cells are sensitive to all lines with same direction.

3. I was also told that ganglions in retina have receptive fields. There are ganglions with on-center and off-center receptive fields. There is also a saccadic motion [J3] (http://en.wikipedia.org/wiki/Saccade), which is essential for visual consciousness: if it is prevented, subject persons first begins to see just darkness and eventually the visual consciousness fades away.

3 Attempt to fuse the pieces to a coherent picture

How to integrate these pieces to a coherent picture? During morning hours this problem popped up in my mind and I got some ideas and decided to check from Wikipedia what is known. I of course thought that this whole thing has been well-understood for decades and maybe it is! If so, I am making myself a fool: it does not however matter much at this age! I found an article about orientations columns [J2] (http://en.wikipedia.org/wiki/Orientation_column) containing a brief mention about a model for how the orientation map is constructed.

So called Moire interference [J1] (see http://en.wikipedia.org/wiki/Moir_pattern) of identical or nearly identical patters rotated with respect to each other by an angle produces a non-localized representation of a definite orientation. By putting the visual representation associated with approximately hexagonal lattices formed by on-centre and off-centre ganglions, one would obtain a representation of orientation somehow. I must be honest: I did not understand the idea at all! Is this really so complex? There was a reference to an article in Nature [J4]: Paik, S., Ringach, D. L. (2011): Retinal origin of orientation maps in the visual cortex. Nature Neuroscience, 14(7), 919-925. I do not have access to this article so that I can continue making naive questions and non-professional arguments.

1. Primary visual cortex performs the roughest processing of visual information. What are the simplest possible visual representations of the external world?

Drawings of course. Painters make first a a sketch. We have cartoons. Visualizations are typically 2-D drawings. It would not be surprising if visual system would not obey the same strategy. In finite resolution they consist of pieces of lines forming what looks like continuous structures when the length of basic piece is short enough as anyone who has used drawing programs knows. Maybe brain and retina first build this kind of representation and add colours and other details later.

2. Could ganglia or possible linear structures formed from them effectively see through slits? They would be specialized to detect the presence of this kind of lines of some minimal length defining the resolution and going through through the centre of retina. When the line is parallel to the slit associated with the detector, the line detector sends nerve pulses to brain.

3. There is a problem. If the orientation of eye remains fixed, the line detector sees only the lines going through the normal of the retina at its centre and usually sees nothing. Most of visual field would remain unseen.

   Saccadic motion saves the situation. When the normal of the line detector intersects the line of visual field with a proper orientation, it detects a line. For a given light intensity the input is maximal if the line is longer than the maximal length of line source for which detector is sensitive. The total intensity of incoming light through the slit is enough to build the representation. The output is bit telling whether a piece of line is there or not.

4. These inputs from slit detectors would be the basic inputs fed to the complex cells forming representations of the lines. In visual cortex the information from the orientation of retina combined with the bits produced by slit detectors during a saccadic motion lasting so long a period that large enough number of orientations of normal are scanned, are combined to a drawing.

   $T = .1$ seconds is the croon of time for sensory percepts. and is the natural guess for this period of integration. The maximal angular speed of saccadic motion is for humans about 900 degrees/second making 90 degrees per time interval T (see `http://en.wikipedia.org/wiki/Saccade`).

   Certainly there must exist a feedback from brain favoring preferred saccades using already existing information about the distribution of lines so that for targets which are stationary saccades would go along the lines of the already existing picture and detect if changes have occurred. The signals from orientation columns of primary cortex might be important part of this feedback.

5. If the object remains in good approximation at rest during this period, a drawing about the external world is obtained as an outcome. The simplest guess is that orientation column at particular point of visual cortex corresponds to a point in the visual field and if there is line of defined direction going through that point of visual field, simple cell sensitive to that orientation receives input.

4 Is quantum coherence in the scale of retina necessary?

1. Could ganglia themselves see the world through a slit? One can argue that if this were the case, it would have been observed experimentally. I tend to agree. One can of course ask whether saccadic motion necessary for visual consciousness effective blurs the visual field of the ganglion so that it is disk of radius defined by the maximal length of line for which ganglion is sensitive.

   The simplest and probably the correct assumption is that ganglia indeed detect spots of light or absence of it. Line detectors would correspond to lines formed by ganglia or perhaps similar structures at higher levels of the neural hierarchy.

2. Together with dark matter realized as a hierarchy of phases with non-standard value $h_{eff} = n \times h$ of Planck constant magnetic flux tubes are the basic building bricks of TGD inspired view about living matter and serve as geometric and topological correlates for macroscopic quantum coherence [K5]). Since flux tubes seem to provide a simple explanation for various anomalies popping up in practically all scales between elementary particle size and cosmic scales (and since I love them), I cannot resist the temptation to connect the ganglia by flux tubes to form these lines so that one would have a grid lines of ganglia analogous to a the radial lines of a coordinate grid of cylindrical coordinates with origin at the centre of retina. Peripheral regions would correspond to a poorer resolution if this is the case. Maybe macroscopic quantum coherence would enter the stage here and allow to bind the percepts about spots to a percept about line.

Of, course this idea is just a first guess reflecting my deep ignorance about how visual representations are formed, and certainly the details, if not the whole idea, are wrong.

REFERENCES

Neuroscience and Consciousness

[J1] Moire patterns. `http://en.wikipedia.org/wiki/Moir_pattern`.

[J2] Orientation column. `http://en.wikipedia.org/wiki/Orientation_column`.

[J3] Saccade. `http://en.wikipedia.org/wiki/Saccade`.

[J4] D. L. Ringach S. Paik. Retinal origin of orientation maps in the visual cortex. *Nature Neuroscience*, 14(7):919–925, 2011.

Books related to TGD

[K1] M. Pitkänen. About Nature of Time. In *TGD Inspired Theory of Consciousness*. Onlinebook. http://tgdtheory.fi/public_html/tgdconsc/tgdconsc.html#timenature, 2006.

[K2] M. Pitkänen. General Theory of Qualia. In *Bio-Systems as Conscious Holograms*. Onlinebook. http://tgdtheory.fi/public_html/hologram/hologram.html#qualia, 2006.

[K3] M. Pitkänen. Magnetic Sensory Canvas Hypothesis. In *TGD and EEG*. Onlinebook. http://tgdtheory.fi/public_html//tgdeeg/tgdeeg/tgdeeg.html#mec, 2006.

[K4] M. Pitkänen. Quantum Model for Sensory Representations. In *TGD Inspired Theory of Consciousness*. Onlinebook. http://tgdtheory.fi/public_html/tgdconsc/tgdconsc.html#expc, 2006.

[K5] M. Pitkänen. Quantum Mind, Magnetic Body, and Biological Body. In *TGD based view about living matter and remote mental interactions*. Onlinebook. http://tgdtheory.fi/public_html/pdfpool/lianPB.pdf, 2012.