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Inspections of human vision by using the photographs on a rotating propeller

Shinji Karasawa

Miyagi National College of Technology (Professor emeritus). 1-3-6, Oyama, Natori-shi, Miyagi-ken, 981-1233 Japan
E-mail: shinji-karasawa@kbh.biglobe.ne.jp

Abstract Mechanism of human vision was inspected by using photographs on a rotating propeller. The recognition on the state of rotating is recognized by the image that flowed. The flowing image is captured when the object moves during the shutter opens. By marking white to a blade in the propeller, the direction of rotation is inspected. The recognized direction depends on the shortest shift of the angle between images before and after. Unconscious vision on the playback gives priority to the recognition of slow rotation on the inclusive image. Sometimes we recognize the element that match with the former element of recognition. The visual recognition is activity, and it depends on the long-term memory and the short-term memory.

Keyword Human vision, Recognition of motion, Recognition of rotating direction, Short-term memory, Digital camera

1. Introduction

Research on vision has been done in the field such as brain science or information science. It is studied by researchers even in the field of engineering on unmanned vehicles and robotics [1]. However, the understanding of the vision is insufficient yet. The author has tried that vision clarifies with concept of the activity that is organized reactions [2], [3].

Although the consciousness is related to the activity of vision, most of the activities are done unconsciously. Author etc. discussed that there is an unconscious motive in vision [2]. The human carries out fundamental reaction by unconscious reactions. The conscious activity of human being was added later. The authors investigated that there are unconscious motivations in the human vision [4]. The conscious activity is the one that was added to an unconscious life activity.

By the way, today's digital camera is implemented various functions those are available to confirm the mechanism of vision. So, the author tried to check the visual phenomenon in which the direction of rotation on a wheel turns in the opposite direction with actual direction As the result, the recognition on direction of rotation is carried out by comparison of images between before and after. The observations provide evidences those indicate mechanism of vision.

2. Biochemical reactions as principle of vision

2.1. The reason that understands continuation of nature by discrete processing

Activity of recognition is carried out by biochemical reactions. The reaction rises up, reaches the peak and disappears. The reaction that is separated along time axis is organized by the next reaction at once. Although paralleling reactions take place in a multicellular organism, the plural of impulsive reactions are organized by the activity of a particular cell.

Data of vision are memorized as connecting points of a nerve circuit, and those are compared on the occasion of recognition. The processing of vision is digital [7],[8],[9].

The nervous system connects cause and effect by impulsive activity, and recognition takes place when the rule is established. Understanding depends on the rule. The rule is linear. The linear is analog. Therefore, the human being understands the world with the sense of analogue.

The world of thinking exists in the world of the language that consists with results of recognition. It is the state of mind that the truth is eternal [10]. The method of logic thinking such that there were words before the beginning is not able to clarify the mechanism of pattern recognition.

2.2. Reactions of nerve cells in vision

As for Biochemical reaction of vision, nerve cells in a retina have been checked in detail [5],[6]. The author tried an explanation of the role of nerve cells those compose human retina [7]. That time, the neurotransmitter discharged from each nerve cell became the evidence that estimates the function of the cell. The mechanism of biochemical reaction in a body has evolved historically.

The atom in a liquid is able to replace the neighboring atoms by thermal motion. The interaction among neighboring atoms affect electronic structure of the atom. So, the chemical reaction that adapts the electronic state to the situation takes place. The result of the chemical reaction remains as the condition of the substance or

substance.

The present biochemical reaction is the one that had been selected with the stage in the early period of creature. The biochemical reaction of living body is realized to the purpose that survives. The unconscious activity of biochemical reaction exists to survive [4].

In a body, plural biochemical reaction occurs and those are fading away at each moment. Those occurrences are compared with decoders of neurons. A selected neuron makes reaction by predicting future from the result of recognition. There are some freedoms in a selection of output, because the future is unknown.

The projection of impulsive activations forms an image. The image memorized by the points of connection in a nerve circuit. The data is similar pattern that is taken by a digital camera. The image data are decoded through template matching in the nerve circuit [8],[9],[10].

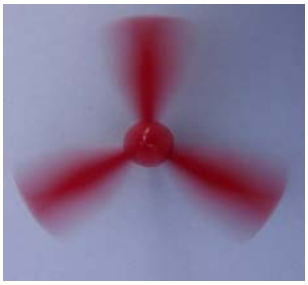
3. How to extract a still image from moving object

3.1. Existence of a shutter in visual processing

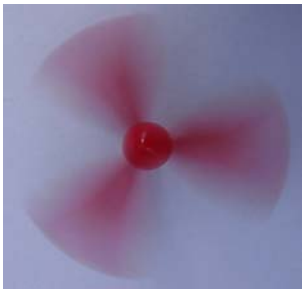
Data on the image that is changing in accordance with time are serial in the real world. The data that continuously changes along time axis must be divided for a processing to understand of arrangements in a space, because the space domain is different from the time domain. And the processing in a nerve system is carried out intermittently. The photographs of this report were taken by using a digital camera "CASIO EX-FH100"[11]. The propeller was rotated by a motor of which axis is connected to the propeller via gearbox with deceleration of 101:1 (or 719:1) in order to avoid rolling shutter effect [refer appendix].

Photographs on rotation of a propeller were taken at 4 kinds of shutter speeds. Those are shown in Fig. 1 (a), (b), (c), (d). The flow of image is large when the period on shutter is long, because the propeller rotates in the period of shutter opened.

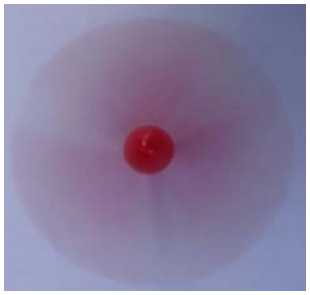
(a) shutter: 1/125 (s)



(b) shutter: 1/60 (s)



(c) shutter: 1/30 (s)



(d) shutter: 1/15 (s)

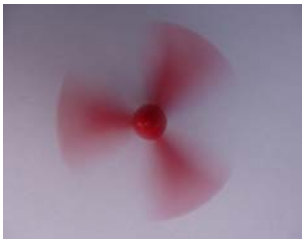
Fig.1 Photographs on a propeller were taken at various shutter speed. In this case, the propeller was rotated at low speed deceleration ratio of 719:1.

In the case that period of shutter fixed, we can estimate the speed of rotation by the picture that flowed. That is, the speed of rotation is recognized by the pattern matching of the motionlessness image that is flowed.

The images shown in Fig.2 are photographed at short time of shutter on high speed of rotation. Fig.2 is similar to Fig.1. That is, the amount of flow in the image depends on the relative relation on the speed between the shutter and the rotation.

(a) shutter: 1/1000(s)

(b) shutter: 1/500 (s)



(c) shutter: 1/250 (s)

(d) shutter: 1/125 (s)

Fig.2 Photographs on a propeller were taken at various shutter speed. In this case, the propeller was rotated at high speed deceleration ratio of 101:1.

4. Recognition on the direction of rotation

4.1. Vision on the image that is photographed under different frame rates

One of blades was painted white in order to clarify the shifting of the rotating angle of propeller. The position of

a blade at the time on a photographing can be projected by high speed of shutter compared with the speed of rotation.

Without changing the rotation of propeller, the photographing with high speed of shutter 1/(1250) (s) was carried out by changing frame rate from 30fps to 120fps.

Those photographs were integrated in a still picture as shown in Fig.3. As for 4 sheets of photographs shown at the upper part, the direction of rotation on the propeller is counterclockwise. But it is difficult to decide the direction of rotation on a white blade. However, the white blade is rotating clockwise clearly in the photographs of the lower part that was photographed with 120 fps on the same rotation.

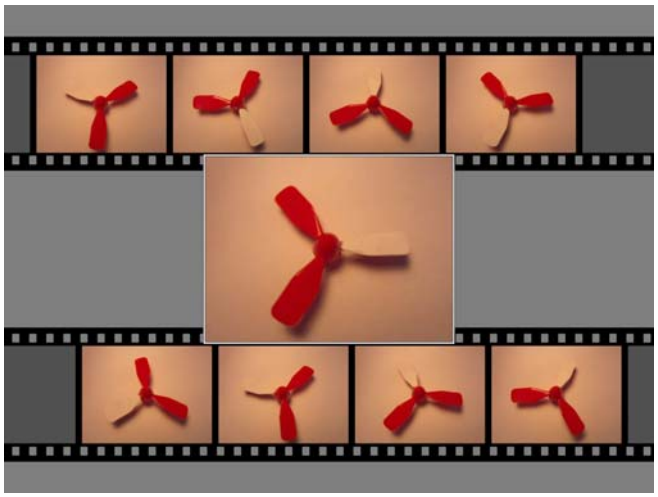


Fig.3 Photographs were taken at different frame rate. Here, the frame rate is 30 frames per second (fps) in upper line, and 120 fps in lower line. The shutter speed is 1/(1250) sec. The propeller rotated at low speed.)

4.2. The case where the direction of rotation on replay looks opposite direction of the actual.

The photographs in Fig.4 are arranged along the progress of time from the left side in upper line and end is right side in lower line. Here, the blade of a propeller was increased from 3 to 6 in order to clarify the shifting of the rotating angle of propeller. The photographing conditions are as follows. Shutter speed is 1/500 (s) and frame rate is 5 fps.

Actual propeller rotates clockwise on the occasion of photographing of Fig.4. But, recognized direction of rotation is counterclockwise in the case of replay of Fig.4. The recognized direction of rotation depends on the shortest shift of the angle between images before and after.

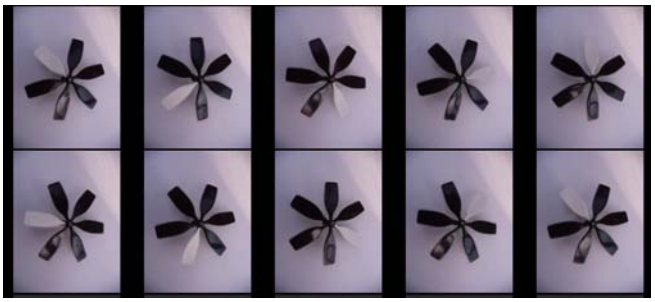


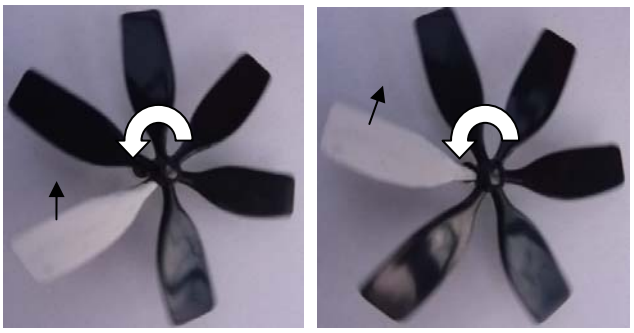
Fig.4 The actual propeller rotates clockwise at the photographing. But the visual recognition on direction of rotation is counter clockwise, if these pictures are replayed as a movie. These photographs were taken at shutter speed of 1/500 sec, and 5 frames per second.

4.3. The image where contradict direction of rotation exists in the same picture

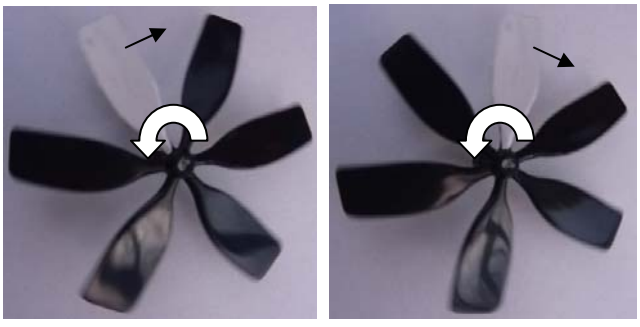
Photographs shown in Fig.5 and Fig.6 were taken at high shutter speed of 1/400 sec, and frame rate of 30 fps.

From these still pictures, we estimate that clockwise rotation for a white blade.

But, we recognize clearly counterclockwise rotation for the whole blade when these images are replayed as movie. We can recognize clockwise rotation for a white blade, if we pay attention to the whole's blade.



(a) No.1, 1/400(s), 30fps (b) No.2, 1/400(s), 30fps



(c) No.3, 1/400(s), 30fps (d) No.4, 1/400(s), 30fps

Fig.5 Photographs were taken at high shutter speed of

1/400 sec, and the frame rate is 30 fps. We estimate that clockwise rotation for a white blade from these still pictures. But, we recognize clearly counterclockwise rotation for the whole blade when these images are replayed as movie.)

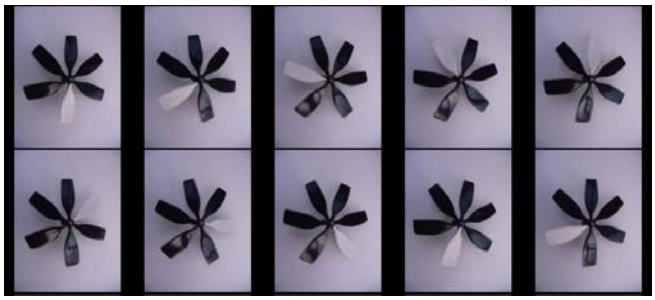


Fig6. These pictures were taken at the same conditions in case of Fig.5. When the pictures are replayed as a movie, we recognize counter clockwise direction of rotation on the whole blade. We recognize clockwise direction of rotation for the white blade, if we pay attention to a white blade.

4.4. The images where the direction of rotation changes suddenly in replaying as a movie

Pictures shown in Fig.7 were photographed at high shutter speed of 1/400 sec, and frame rate of 15 fps. Here, the propeller rotated low speed.

The rotation of the blade changes the direction from anti-clock wise to clock wise, if these pictures are replayed as a movie. The reason is that unit shift of blade is slightly large than 1 plus half. That is, the deviation of shift changes the shortest distance blade and caused the change of the recognition. The shifting of the inclusive picture that does not notice in the still picture is recognized sensitively at the recognition of movie.

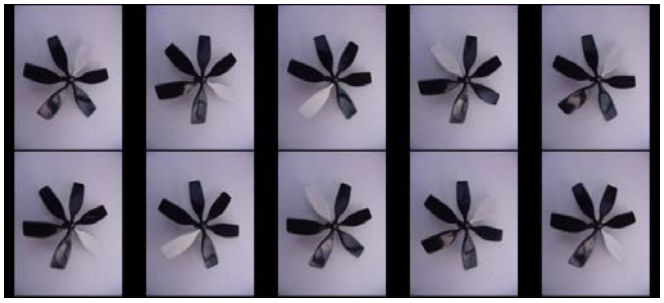


Fig.7 Photographs were taken at high shutter speed of 1/400 sec, and the frame rate is 15 fps. The rotation of the blade changes the direction from anti-clock wise to clock wise, if these pictures are replayed as a movie. The reason is that unit shift of blade is slightly large than 1 plus half.

5. The priority of vision given to slight rotation of inclusive picture

5.1. Recognition of rotational direction on whole blades affects recognition of a part

Photographs shown in Fig.8 were taken at high shutter speed of 1/400 sec, and the frame rate of 7 fps. Here, the propeller rotated low speed.

From the still pictures, it is estimated that the whole blade is rotating towards clockwise. A white blade intermittently shifts a little over 360 degrees towards clockwise. So, the white blade shifts over 180 degrees towards clockwise for each frame. Then, the white blades will be rotating counterclockwise.

But the white blade rotates clockwise with the whole propeller while replay as movie. This is one of the evidence that gives the priority to inclusive recognition more than part of recognition.

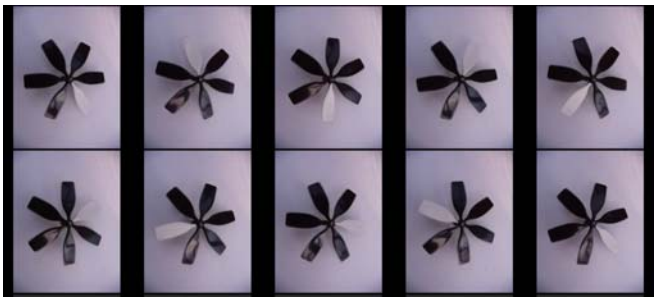


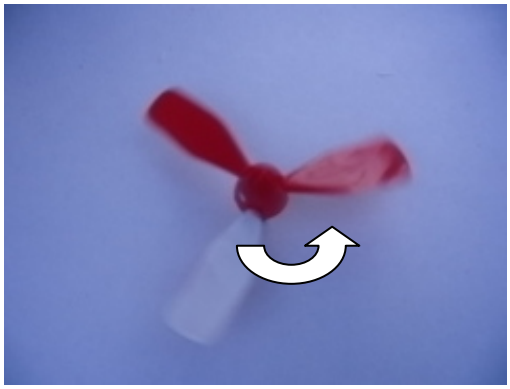
Fig.8 Photographs were taken at high shutter speed of 1/400 sec, and the frame rate of 7 fps. The white wing is rotating barely counterclockwise from the still pictures. But the white blade rotates clockwise with the whole propeller while replay as movie

5.2. The rotation of inclusive image that is not clear in a still picture appears in replay

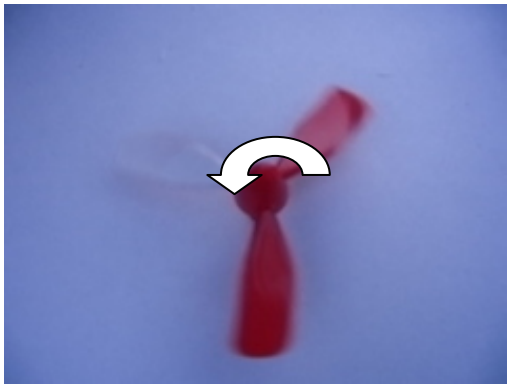
Photographs shown in Fig.9 (a) ,(b), (c) were taken at high shutter speed of 1/(200) sec, and the frame rate of 15 fps. Here, the propeller rotated low speed.

From these still pictures, it is estimated that a white blade and two red (gray) is rotating towards clockwise.

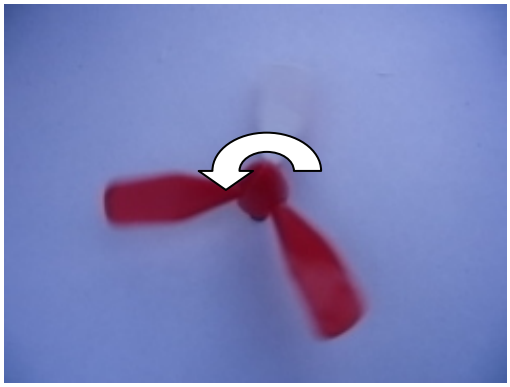
The rotational direction of whole blade can be recognized if we ignore of the color (shading) of blades. That is, the rotational direction of the whole blade is towards counterclockwise as shown by a white arrow in Fig.9.



(a) No1 15 fps, 1/200 (s)



(b) No2 15 fps, 1/200 (s)



(c) No.3 15fps, 1/200 (s)

Fig.9 Photographs were taken at high shutter speed of 1/500 sec, and the frame rate is 5 fps. The visual recognition of direction of rotation is counter clockwise, if these pictures are replayed as a movie.)

At replay of pictures as a movie, the counterclockwise rotational direction as shown by arrow in Fig.9 is recognized clearly. Even at replay as a movie, the clockwise rotational direction of the white wing can be recognized when the attention is paid to a white wing.

Moreover, the clockwise rotational direction of the red (gray) wing can be recognized when attention is paid to those blades.

6. Application to the vision device that makes use of extracted data as reference.

The big problem on the vision device is the segmentation of a processing unit. The method similar to the vision of human is as follows. At first, the data of the target are taken from central part of a view. Without putting time, the data for the object is taken from the center of the view. Calculations have to be done to get the displacement that yields minimum difference. By using the result, the alignment of a focus point to the object can be done. The device that is able to continue focusing on an object. The processing of comparison between a set of data is available to calculate movement of the camera or to construct the world molding.

The comparison of paralleling data of an image is easy carried out by an integrated circuit. A LSI system for automatic implementation of sifter (a kind of decoder) was proposed by using MOF FET as a transmission gate [12]. The device is able to use as an encoder or as a decoder by exchanging the load to the signal source.

A computer is available to the processing. But the serial processing takes time. In the computer processing, amount of pixel must be decreased to a necessary minimum. The photograph of small amount of pixel (16x16) is shown in Fig. 10.

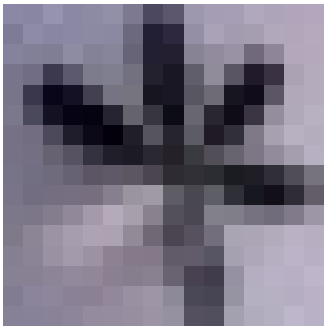


Fig.10 A photograph on a propeller with small number of pixels (16x16))

7. Conclusions

The dynamic characteristics on human vision were studied by using pictures of the rotating propeller of which one of blade was marked.

The picture of propeller flows, when a propeller rotates in period of photographing. The flow in the picture is decided in relative relation between the moving speed and the speed of shutter. For human vision, rotational speed of the propeller is recognized by a pattern matching of the still image that is flowing.

The recognition of rotational direction is not pattern

recognition and it is done with the comparison of the image between before and after. In comparison with the analysis on still pictures, the priority is given to the recognition of rotational direction on the inclusive image. It is conceivable that the priority is related to the construction of the world model.

From these results, the principle of vision was inspected. i.e.「The mechanism of understanding of the real world is composed of rules of biochemical reactions. [7], [8], [9], [10]」

The human gathers information from the image consciously. Human is able to control vision with the language activity. But the language use is newly added function in a brain. It is overlapped with unconscious activities. Most of the processing in the brain is processed in unconsciousness. It is not random processing and it is necessary activity for the purpose of survive.

The author hopes that this report contributes to development of science on the vision and technologies on unmanned vehicle or robotics.

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[Appendix]

Distortion of image that is caused by rolling shutter of c-MOS-sensor

The distortion as shown in Fig. 11 is observed in the picture on a high speed rotating propeller if the digital camera with CCD sensor is used. The distortion of image that is shown in Fig.11 occurs by the method of picking up of data. The rolling shutter reads out the data by scanning similar to that of cathode-ray tube.

When the propeller rotates clockwise, the picking of the data is delayed at the lower line. The data on advanced position is gathered at lower position.

On scanning from the left side, the period of integration becomes long in the right side. The data of propeller exists in a wide range by the shift of propeller in that period. The flow of image that data spreads in wide area increases in the right side.

Both effects are synthesized and the distortion appears as shown in Fig. 11.

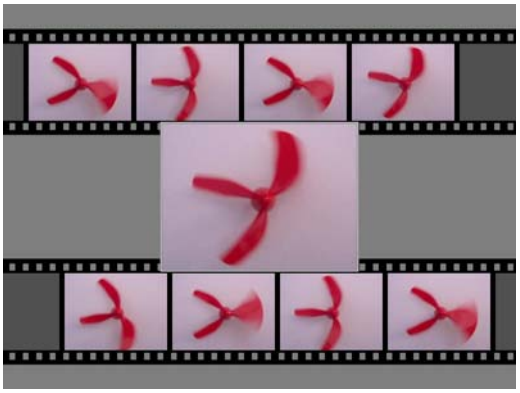

Fig.11 Photographs those indicate the effect of rolling shutter. The photographs were taken on a propeller with high speed of rotation.