The 2nd German-Japanese Workshop on "Nonlinear Science and KANSEI-Informatics ",
29th August, 2013 (Yamaguchi, Japan)

From Nonlinear Science to Perceptual Sciences and Design Engineering
(Emergence in Vision)

H. Miike (Yamaguchi University)

Thanks to all participants

- Organizers:

・K. Koga, H. Hashimoto, K. Nakajima, Y. Hisanaga, T. Sakurai, A. Osa, Y. Mizukami, K. Okada, S. Tsukamoto, A. Nomura, T. Yamada, and M. Momota

- Speakers and Other Participants:

・Y. Kuramoto, S. Kai, S. Mueller, H. Brand, K. Tsuji, T. Yamaguchi, E. Yokoyama, S. Nakata, M. Ichikawa, T. Amemiya, T. Asai, H. Mahara, R. Kobayashi, ・・・

I really appreciate your efforts and kindness to have such a nice workshop!

A pathway leading to the **Kyushu national museum** and **Koumyoji（光明寺） Zen temple**.

Dazaifu city, Fukuoka (1948-1960)
(My birthplace)

http://www.dazaifu.org/map/map-en.html

A Map of Dazaifu City

①Dazaifu Tenmangu Shrine for M. Sugawara 太宰府天満宮

A pathway leading to the **Kyushu national museum** and **Koumyoji Zen temple（光明禅寺）**.

Dazaifu city, Fukuoka (1948-1960)
(My birthplace)

1．A Historical Sketch of My Studies

- 1970-1975: School Days (Kyushu Univ., Fukuoka)
  - ・Critical Phenomena, Phase Transition in Low-Dimensional Magnetic Materials (KCuF3, K2CuF4, etc.) : Period O
  - **(Condensed Matter Physics)**

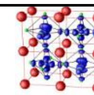
1976: First Assignment to Yamaguchi University (Ube, Japan)

- 1976-1986: Period Ⅰ (+ Biomedical & Information Eng.)
- 1987-1995: Period Ⅱ (+ Nonlinear Sci. & Image Proc.)

1987: Post Doctoral Fellowship in MPI (Dortmund, W-Ger.)

- 1996-2013: Period Ⅲ (+ Perceptual Sci. & Design Eng.)

O. 1970-1975: Heat transport by magnon in KCuF3



Doctor Thesis (1976):

Anomalous Thermal Conduction Induced by Critical Dynamics of Spin Waves in the Order of Low-Dimensional Magnet

Journal of the Physical Society of Japan, Vol. 38, No. 5, May, 1975

Evidence of the Diffusive Thermal Conduction in a One-Dimensional Antiferromagnet $KCuF_3$ above T_N.

Hidetoshi Miike and Kazuyoshi Hirakawa
Department of Electronics Engineering, Kyushu University, Fukuoka

(Received November 21, 1974)

The thermal conductivity of a quasi one-dimensional antiferromagnet $KCuF_3$ has been measured. A large enhanced conductivity in the direction of a linear magnetic chain is observed above T_N. The results of analysis based on Huber's theoretical prediction and the dynamical scaling hypothesis indicate that the behavior of the enhanced conductivity can be understood as an energy diffusion in the linear magnetic chain.

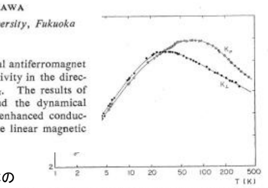


Fig. 3. The temperature dependence of the thermal conductivity of $KCuF_3$
; $K_{\parallel}$ (heat//chain)
; $K_{\perp}$ (heat⊥chain)

熱伝導度を通して見た低次元磁性体の臨界現象・相転移

Ⅰ．1976-1980 : Cholesteric Liquid Crystal

Journal of the Physical Society of Japan, Vol. 44, No. 5, May, 1978

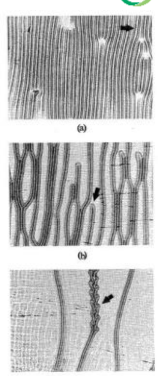
The Instability of Planar Texture in Cholesteric and Nematic Mixture with the Negative Dielectric Anisotropy

Tatsuhiko Kohno, Hidetoshi Miike and Yoshio Ebina
Department of Electrical Engineering, Yamaguchi University, Ube

(Received December 15, 1977)

The induced patterns under ac. electric field are examined in the dilute cholesteric and nematic mixtures with the negative dielectric anisotropy. The instability in the planar texture is triggered by a material flow at threshold voltage and regular periodic patterns can be observed by using the polarizing microscope. The patterns are deformed due to the formation of axial disclinations with increasing the field. The deformation is stabilized by making the new planar texture under the applied field. The number of twists increases in the new planar texture. When we increase the field further, the instability occurs in the new planar texture. A new mechanism for succeeding transitions is proposed. Both the electrohydrodynamic instability and the contraction of the cholesteric pitch are important in the mechanism.

コレステリック液晶の電気光学効果（パターン形成）



Ⅱ．1983-: Image Sequence Processing (Early Stage)

Japanese Journal of Applied Physics
Vol. 23, No. 6, June, 1984 pp. L379–L381

動画像処理 Ⅰ

New Dynamic Image Processing Technique for the Analysis of Texture Movement: Study of the Dissipative Structure in the Electrohydrodynamic Instability of Nematic Liquid Crystal

Hidetoshi Miike, Syunichi Ikemoto, Kouji Ochiai, Hajime Hashimoto and Yoshio Ebina
Department of Electrical Engineering, Yamaguchi University, 2557 Tokiwadai, Ube 755

(Received March 16, 1984; accepted for publication May 26, 1984)

A dynamic texture image processing technique is developed. A moving texture is sampled every 0.42 s and a time series of 128 dynamic frames is obtained. Each frame is constructured by 32 × 32 pixcels with 64 gray scale levels of brightness. From the time course of each pixcel's brightness, a correlation time and a variance are calculated; then a "correlation image" and "variance image" of the moving texture are constructed. This technique is applied to the analysis of dissipative structures in the electrohydrodynamic instability of nematic liquid crystal. Interesting information about dynamic behavior is obtained.

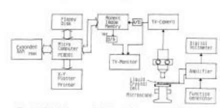


Fig. 1. Block diagram of the dynamic image processing system.

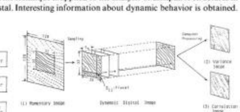


Fig. 2. Sampling procedure of the dynamic image. The dynamic picture is sampled every 0.42 s, and 128 dynamic frames are obtained. Each frame is constructed by 32 × 32 piscels with 64 gray scale levels of brightness.

Ⅱ．1987- : Nonlinear Sciences (BZ-reaction)

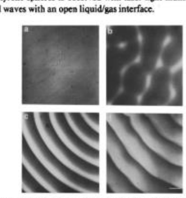
化学反応に伴う流体現象とパターン形成

OSCILLATORY HYDRODYNAMIC FLOW INDUCED BY CHEMICAL WAVES

Hidetoshi MIIKE [1], Stefan C. MÜLLER and Benno HESS
Max-Planck-Institut für Ernährungsphysiologie, Rheinlanddamm 201, D-4600 Dortmund 1, Federal Republic of Germany

Received 30 December 1987

Hydrodynamic flows in a reactive liquid induced by the propagation of waves of chemical activity are investigated for the ferroin-catalyzed Belousov–Zhabotinskii reaction in thin layers by microscope video imaging techniques. The motion of added polystyrene spheres is observed with laser light illumination. Oscillations in the hydrodynamic flow were detected in rotating spiral waves with an open liquid/gas interface.



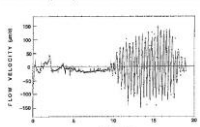
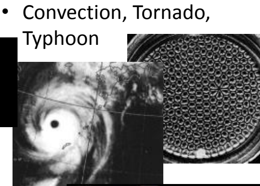


FIG. 2. Time trace of extremely pronounced flow oscillation in a covered BZ-solution layer (preparation as in Fig. 1) with a free liquid/gas interface. Temperature: 26 °C. Solid circles are obtained manually by tracing the moving particles in the video movie (Ref. 16). The solid line shows a result obtained by automatic analysis through dynamic image processing [2D velocimetry (Ref. 20)], confirming the reliability of the velocimetry method.

Emerging Phenomena in Nature
（自然界における多様な創発現象）

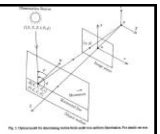
- Chemical Reaction
- Convection, Tornado, Typhoon



- Biological Self-Organization

Ⅱ. 1986-: Image Sequence Processing (Developing Stage) 動画像処理Ⅱ

March 1995
Pattern Recognition Letters
Pattern Recognition Letters 16 (1995) 285–296



Determining motion fields under non-uniform illumination

Atsushi Nomura [a], Hidetoshi Miike [b,*], Kazutoshi Koga [c]
[a] Department of Cultural and International Studies, Yamaguchi Women's University, Sakurabatake 3-2-1, 753 Yamaguchi, Japan
[b] Department of Electrical and Electronic Engineering, Yamaguchi University, Tokiwadai 2557, 755 Ube, Japan
[c] Department of Computer Science and Systems Engineering, Yamaguchi University, Tokiwadai 2557, 755 Ube, Japan

Received 30 October 1993; revised 26 September 1994

Abstract

Two realistic methods based on a generalized conservation equation of image brightness are proposed for the accurate determination of motion fields under non-uniform illumination. The conservation equation includes spatial and temporal derivatives of image brightness, a motion vector and a rate of brightness generation. The term for the brightness generation rate can represent non-stationarity of a brightness pattern during its motion under non-uniform illumination. By introducing an optical model and prior knowledge of non-uniform illumination the conservation equation can be solved. One of the two proposed methods assumes a stationary motion field under spatially non-uniform illumination. The other assumes local constancy of a motion field under temporally non-uniform illumination. The application to artificial and real image sequences confirms the usefulness of the proposed methods.

Keywords: Motion field; Non-uniform illumination; Local optimization; Temporal optimization; Conservation equation

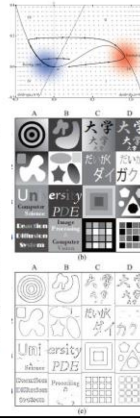
山口大学

Ⅱ. 1999-: Nonlinear Science & Image Processing （非線形科学を基礎とする画像処理）

INTERNATIONAL JOURNAL OF CIRCUITS, SYSTEMS AND SIGNAL PROCESSING

Edge Detection Algorithm Inspired by Pattern Formation Processes of Reaction-Diffusion Systems

Atsushi Nomura, Makoto Ichikawa, Koichi Okada, Hidetoshi Miike and Tatsunari Sakurai



山口大学

Ⅲ. 1996-: Perceptual Sciences and Design Engineering （感性科学とデザイン工学）

Japanese Psychological Research
2008, Volume 50, No. 3, 117–127
doi: 10

Magnification rate of objects in a perspective image to fit to our perception

KAZUMI NAGATA
Faculty of Engineering, Yamaguchi University, Japan
ATSUSHI OSA
Graduate School of Science and Engineering, Yamaguchi University, Japan
MAKOTO ICHIKAWA
Faculty of Letters, Chiba University, Japan
TAKESHI KINOSHITA and HIDETOSHI MIIKE*
Graduate School of Science and Engineering, Yamaguchi University, Japan

Abstract: A landscape photograph may give a different impression from that formed at the real scene, with respect to the size and distance of objects. Researchers have reported that the perceived sizes and distances of objects in a photograph are not identical to those in a real space. In order to develop a method to create a graphic image that is close to our visual impression as seen in the real space, two experiments were conducted. In Experiment 1, we examined how the magnification rate of the perceived size to the object size on the retina varied with the viewing distance (range was from 1 m to 10 m). In Experiment 2, we examined whether transformation based on the magnification rate is effective for creating an image that matches the perceived size of the object at the scene. Our results indicate that the magnification rate is useful for transforming the perspective image to match our perception of the objects regardless of the viewing distance.

Key words: perceived size, distance, location, perspective image, photograph.

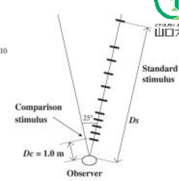


Figure 1. Location of the stimuli when *Dc* was 1.0 m.

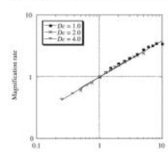


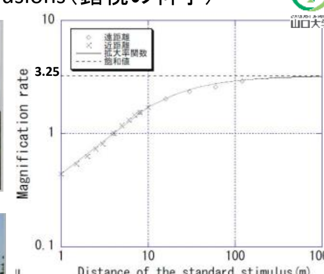
Figure 3. Dependence of the magnification rate on the normalized viewing distance to the comparison stimulus. The horizontal axis is *Ds/Dc*.

山口大学

Geometric Optical Illusions（錯視の科学）

Size Magnification

Angle Illusion



$$f(D) = e^{A}$$

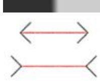
$$A = \frac{\alpha N_0 D^{\alpha}}{\alpha + \lambda N_0 (D^{\alpha} - 1)} - C$$

山口大学

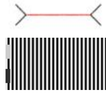
2. Recent Interests and Topics （最近の話題）

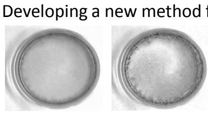
- **Understanding visual function and visual illusions inspired by nonlinear science.**

1) Visual (Optical) illusions
・Mach band, Muller-Lyer illusion
・Simulating footsteps illusion



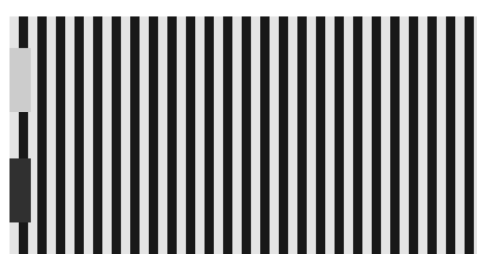
2) Motion Sharpening
・Modeling motion sharpening
・Developing a new method for motion sharpening





山口大学

1）Motion Illusions: Footsteps Illusion



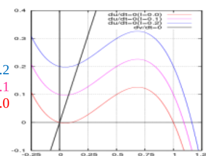
S. Anstis, *Footsteps and inchworms: Illusions show that contrast affects apparent speed*, Perception,Vol.30 (2001), No.7, pp.785-794

Modeling Footsteps Illusion

- An Extended FitzHugh-Nagumo (FHN) Model with Continuous Input.

$$\begin{cases} \dfrac{du}{dt} = d_u(U-4u) + \dfrac{1}{\varepsilon}\{u(u-a)(1-u) - v + I\} \\ \dfrac{dv}{dt} = d_v(V-4v) + u - bv \end{cases}$$

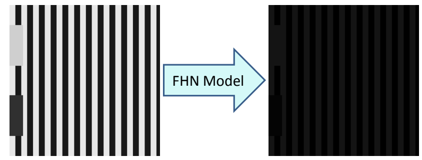
- Variables : $u = u_{i,j}(t)$, $v = v_{i,j}(t)$
- Input : $I = I_{i,j}(t)$
- Output : $u_{i,j}(t)$
- Initial Values : $u_{i,j}(t) = v_{i,j}(t) = 0$



K. Miura et al., IEEJ Trans. EIS, Vol.129 (2009), pp.1156-1161

Results : Image Sequence of Output $u_{i,j}(t)$

- Parameters for Input *I(t)*
  - Stripe : Width10pix. Brightness 0.1 & 0.9
  - Moving Object : Width 23pix. Brightness 0.2 & 0.8

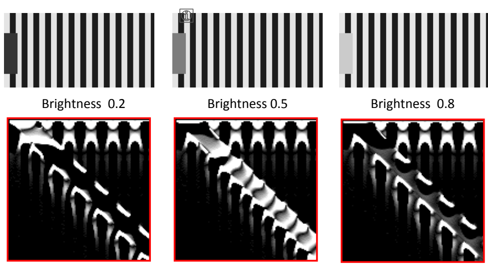


Input *I(t)* Output *u(t)*

We have to visualize intermittency of the motion.

Dependence on the Brightness of the Moving Object

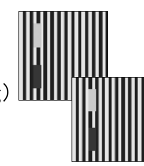
- Visual Illusion: Depends on the Contrast Change



Higher Contrast Brings Clear Intermittency.

Discussion : Cause of Motion Illusion

- Interpretation by Sunaga *et al.*(2008)
  - Dislocation Illusion Induced by the Stimulus Image is the Main Cause of the Motion Illusion.
- Characteristics of FitzHugh-Nagumo Model
  - Smoothing Effect (controlled by εd_u)
  - Contrast Enhancement (Threshold Firing)



$$\begin{cases} \dfrac{du}{dt} = d_u(U-4u) + \dfrac{1}{\varepsilon}\{u(u-a)(1-u) - v + I\} \\ \dfrac{dv}{dt} = d_v(V-4v) + u - bv \end{cases}$$

Characteristics of FitzHugh-Nagumo Model Enhance the Dislocation Illusion.

Summary : Footsteps Illusion

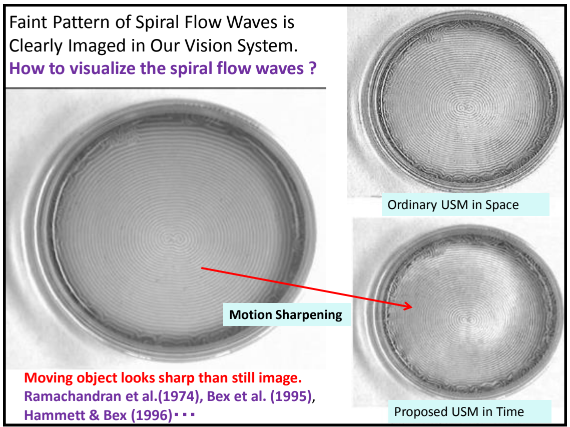
- Characteristics of Footsteps Illusion are Reproduced by the Extended FitzHugh-Nagumo Model.
- Reproduced Characteristics:
  - The Less Stripe Width Brings the Less Illusion.
  - The More Brightness of Moving Object Brings the More Intermittency of the Motion.
  - Brightness Change Appears in the Moving Object.

2) Emergence in Vision: Motion Sharpening

- Best Example of Motion Sharpening:

Faint Pattern of Spiral Flow Waves is Clearly Imaged in Our Vision System.

How to visualize the spiral flow waves ?



Moving object looks sharp than still image.
Ramachandran et al.(1974), Bex et al. (1995), Hammett & Bex (1996)・・・

Image Sharpening Algorithm:

- Unsharp Masking in Space (USM)

(a) Original Image (b) Unsharp Mask (C) Sharpening Image

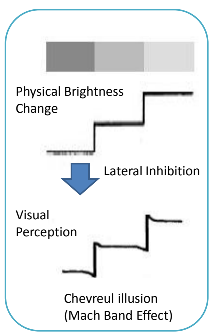
- Unsharp Mask= Smoothing + Reversal Processing (negative to positive)
- Convolution Carnell for USM:

	-1	0
-1	5	-1
0	-1	0

The reason why USM brings sharp perception:

- Chevreul Brightness Illusion (Mach Band Effect)
- USM Enhances Lateral Inhibition Function of Retina (Low Level Vision).

USM is an image enhance method utilizing lateral inhibition function observed in Chevreul Illusion.



Realizing Motion Sharpening & Enhancement :

- First, we proposed a motion enhancement method to visualize a faint nonlinear dynamics (PRL, 1999).

ELSEVIER Pattern Recognition Letters 20 (1999) 451–461
Pattern Recognition Letters
www.elsevier.nl/locate/patrec

Motion enhancement for preprocessing of optical flow detection and scientific visualization

Hidetoshi Miike [a,*], Lin Zhang [a], Tatsunari Sakurai [a], Hidemi Yamada [b]
[a] Graduate School of Science and Engineering, Yamaguchi University, 2557 Tokiwadai, Ube 755-8611, Japan
[b] Tokuyama College of Technology, Tokuyama 745, Japan

Received 7 May 1998; received in revised form 25 January 1999

Abstract

We introduce a simple method for motion enhancement. The method enables us to realize brightness enhancement of moving objects, to reduce the influence of non-uniform illumination in motion analysis and to visualize dynamic streamlines in fluid flow analysis.

Keywords: Motion enhancement; Optical flow; Temporal filtering; Image sequence; Pixel-based processing

Pattern Recognition Letters 20 (1999) pp. 451-461

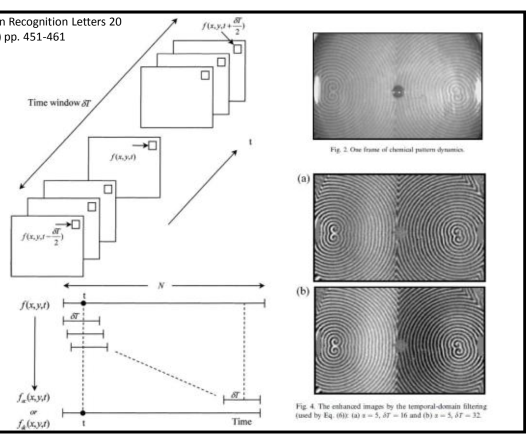


Fig. 2. One frame of chemical pattern dynamics.

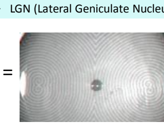
Fig. 4. The enhanced images by the temporal-domain filtering (used by Eq. (6)): (a) a = 5, δT = 16 and (b) a = 5, δT = 32.

Realizing Motion Sharpening & Enhancement :

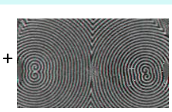
- Second, we proposed a temporal unsharp masking method (t-USM, A. Osa, K. Otaka, et. al., 2009) to realize motion sharpening effect.
- Models for the motion sharpening:
  1) Pääkkönen & Morgan Model: Bipolar Time Impulse Response Function of Visual System (2001)
  2) Hammett et al. Model: Magnocellular cell route in LGN* is sensitive to motion but saturates easily to signal intensity (2004).

  * Retina → LGN (Lateral Geniculate Nucleus) → Visual Cortex → Brain

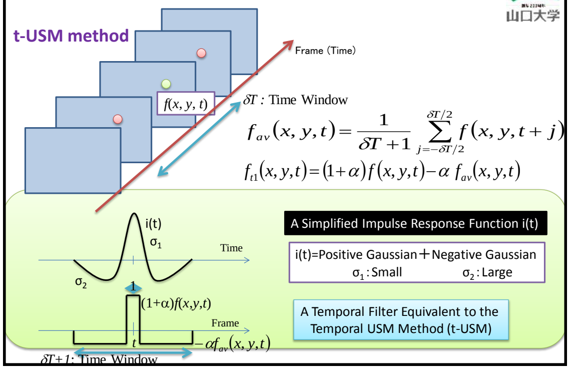
- t-USM =



+



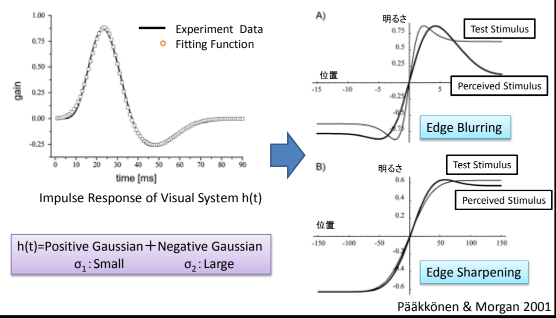
Proposed Method: Temporal USM method is modified based on the visual model by Pääkkönen & Morgan.



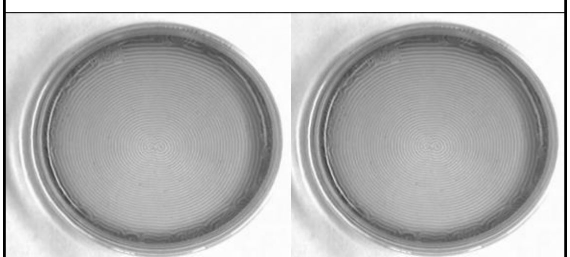
$$f_{av}(x,y,t)=\frac{1}{\delta T+1}\sum_{j=-\delta T/2}^{\delta T/2} f(x,y,t+j)$$

$$f_{t1}(x,y,t)=(1+\alpha)f(x,y,t)-\alpha f_{av}(x,y,t)$$

Pääkkönen & Morgan : Bipolar Impulse Response Model

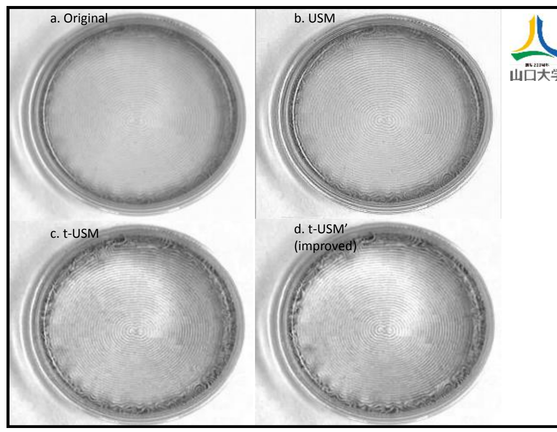


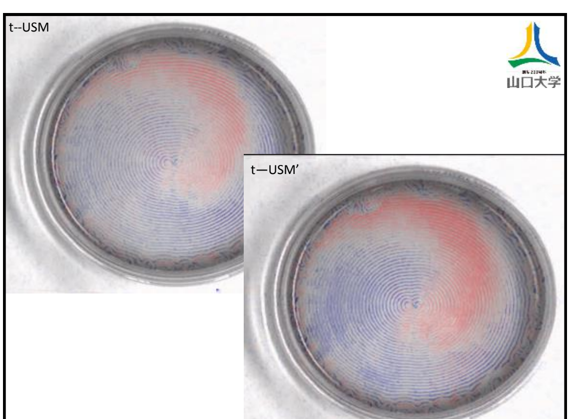
Result : Spiral Flow Waves in BZ Reaction

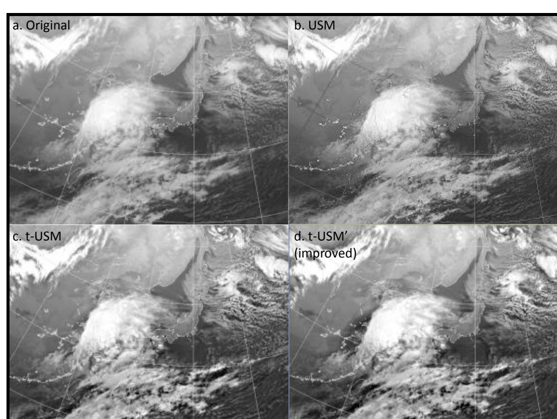


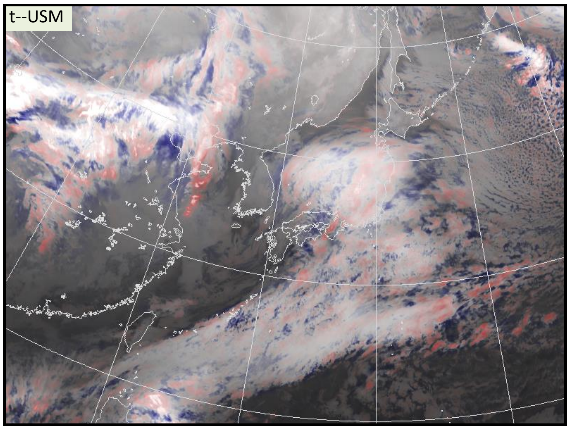
(a) Original Image Sequence

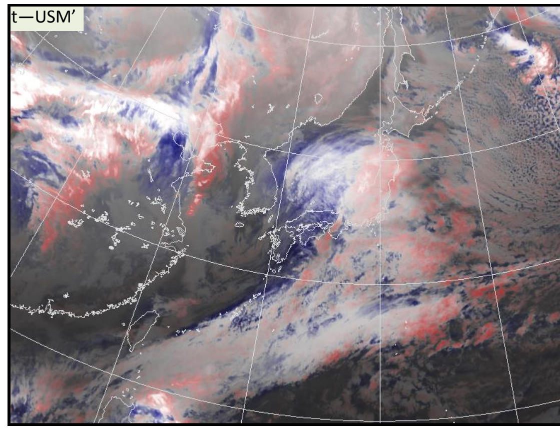
(b) Filtered Image Sequence by t-USM (from K. Otaka)











Summary ：Motion Sharpening

- Enhancement and/or sharpening of image sequence is realized by a temporal USM (t-USM) method.
- Recently, we improved the t-USM method (t-USM’).
- Characteristics of the proposed method:
  - There is no enhancement for the still objects in the sequence.
  - Depending on the shape of edge and moving velocity, edge sharpening and contrast enhancement are realized.
  - Moving patterns hard to detect in the respective still image can be enhanced by the t-USM’ method.

Our next subject = Finding nonlinear model to realize motion sharpening in a self-organized fashion.

The 2nd German-Japanese Workshop on “Nonlinear Science and KANSEI-Informatics ”
29th August, 2013 (Yamaguchi, Japan)

3. Conclusion

3. Conclusion

- We have proposed discrete FitzHugh-Nagumo models. The nonlinear models show curious characteristics as follows.
  1) Edge detection and figure-ground separation are realized in a self-organized fashion by the models.
  2) Footsteps illusion and its psychological features are reproduced by extending the discrete FHN-models.
- Enhancement and/or sharpening of image sequence is realized by the temporal USM (t-USM) methods.
- **Thus, we believe that complex phenomena observed in our visual system are explained by nonlinear dynamics. This can be “Emergence in Vision”.**
  視覚における創発現象

Emergence in Vision: *Nonlinear Models for Motion Illusion and Motion Sharpening*

Related Studies on Visionary Emergence: Understanding Visual Processing and Visual Illusions Based on Nonlinear Sciences.

- L. Kuhnert et al., Image processing using light-sensitive chemical waves, Nature, 337(1989), pp.244-247
- E. Ueyama et al., Figure-ground separation from motion with reaction-difuson equation, IEICE, J81-D- Ⅱ (1998), pp.2767-2778
- A. Nomura et al., Solving random-dot stereograms with a reaction- diffusion model・・・, in Proc. 10th International DAAAM 1999, p.385
- N.G. Rambidi et al., Image processing using light-sensitive chemical waves, Physics Letters A, 298(2002), pp.375-382
- A. Nomura et al., Realizing visual functions with the reaction-diffusion mechanism, J. Phys. Soc. Japan, 72(2003), pp.2383-2393
- M. Ebihara et al., Image processing by a discrete reaction-diffusion system, in Proc. Third IASTED Int. Conf., 1(2003), pp.378-385
- K. Miura et al., Self-organized feature extraction in a three-dimensional discrete reaction-diffusion system, Forma, 23(2008), pp.19-23
- A. Nomura et al., Reaction-diffusion algorithm for stereo disparity detection, Machine Vision and Applications, 20(2009), pp.175-187
- K. Miura et al., A simulation of the footsteps illusion using a reaction diffusion model, IEEJ, 129(2009), pp. 1156-1161

Thank you for your kind attention.