映像の動きベクトルと生体信号による映像酔いの評価
Assessment of Cybersickness by the Motion Vectors and Biosignals

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Abstract: Virtual reality (VR) is a promising technology in biomedical engineering, but at the same time enlarges another problem called cybersickness. We used the motion vectors to quantize image scenes and measured electrocardiogram, blood pressure, and respiration for evaluating the autonomic regulation. Using the estimated motion vectors, we further synthesized random-dot pattern images as contents-free images. In a test by synthesized images, we surveyed which component of the global motion vector seriously affected the autonomic regulation. The results showed that the zoom component would induce sickness and under unpleasant situation the time-frequency representation of motion vectors revealed the switching behavior of a dominant vibration frequency that was related to camera work.

Approaches

1．**Database of Biosignals affected by Vection-Induced Images**：映像生体影響の出現が確認されている映像に対し，生体信号でみられた特徴のデータベース化

2．**Featuring the Components of Image by Motion Vectors**：動きベクトルによる映像要素の特徴づけ

3．**Analysis by Synthesized Images**：映像要素を様々に変えたシミュレーション映像を制作し，映像生体影響を解析

4．**Estimation of System Function by Multivariate ARX Model**：映像の動きベクトルを入力とし、自律神経系の概周期的な生体信号（心拍変動や呼吸波形、血圧波形など）を出力とする多変量ARXモデル推定

Rating of Image（映像のレイティング）

Strength of Unpleasant Impression under Vection-Induced Images

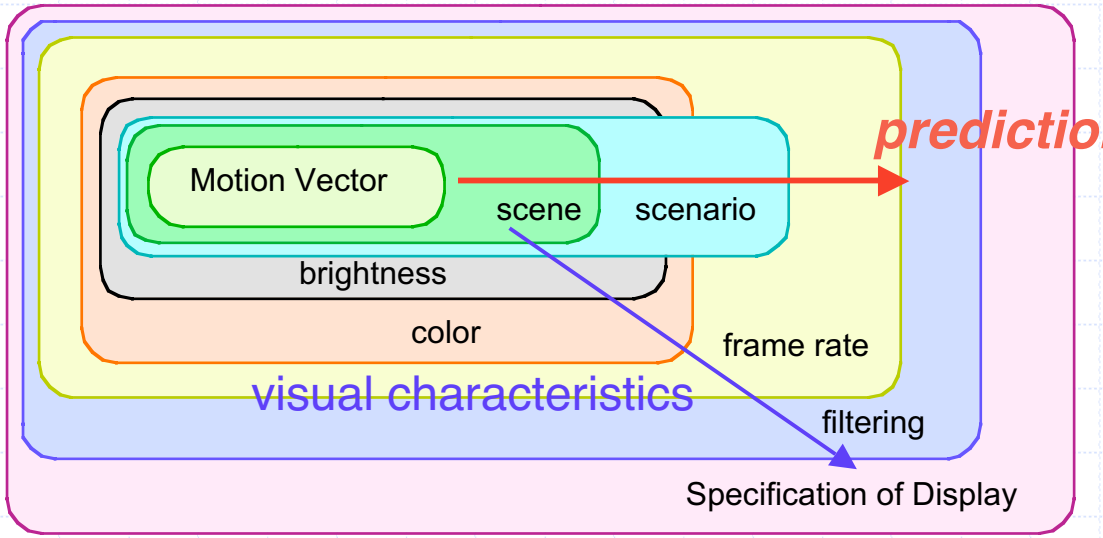
= (*prediction-required level for images*)

× (*experience for image contents*)

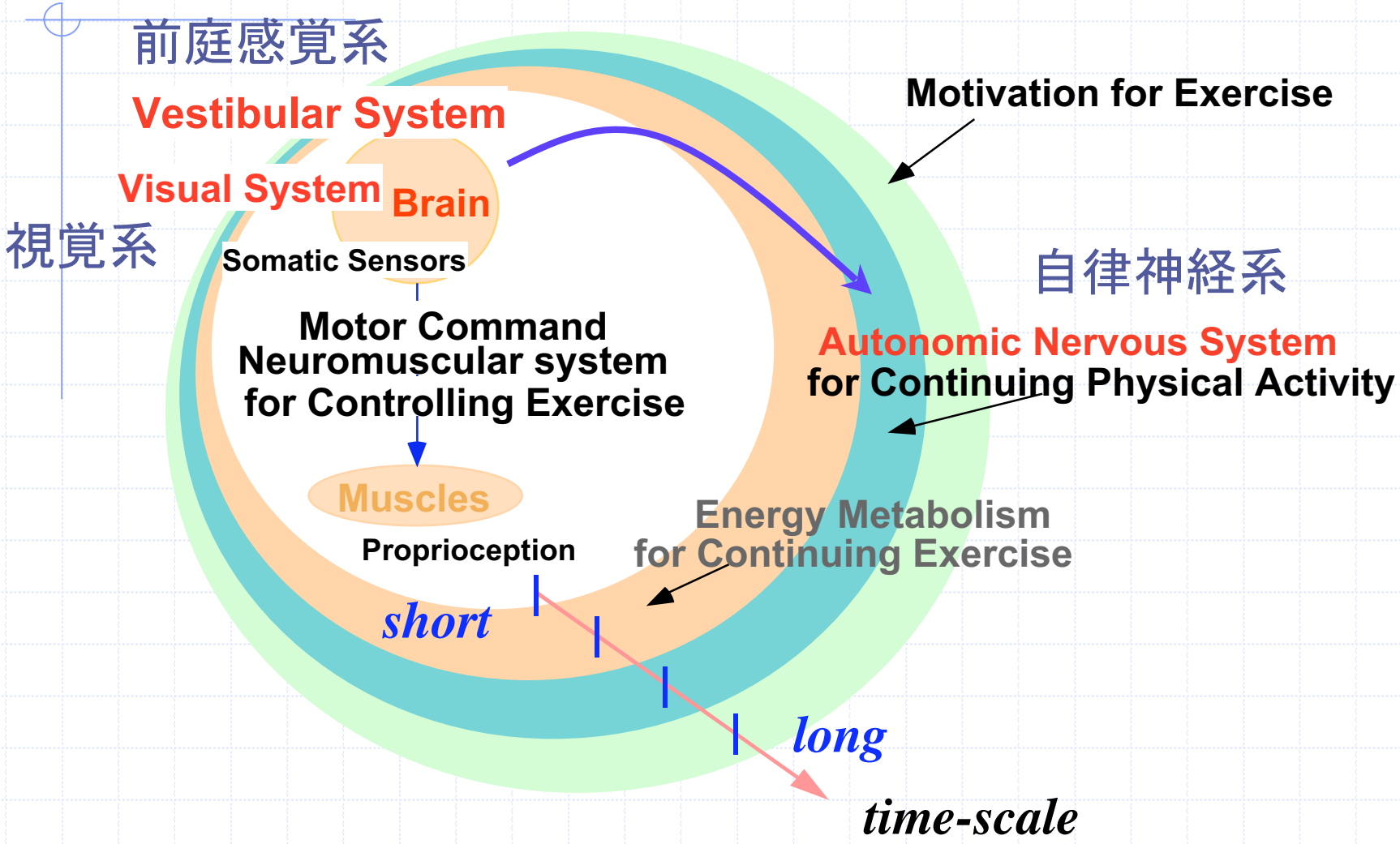
× (*brightness, frame size, and frame rate etc.*)

targets for evaluation

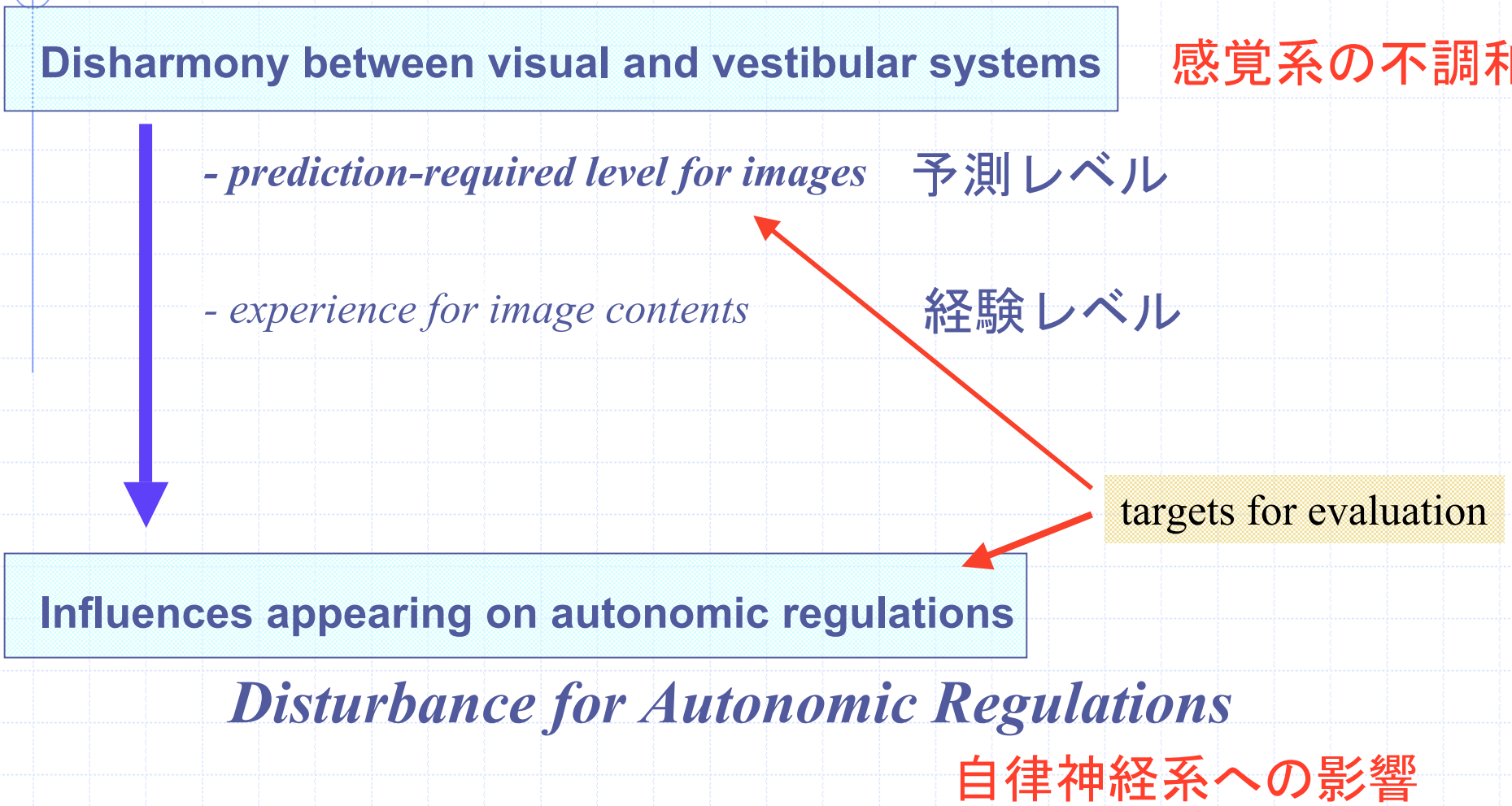
Hierarchy of image components



Several Time-Scales in Biosignals



Rating of Personal Features
（個人性のレイティング）



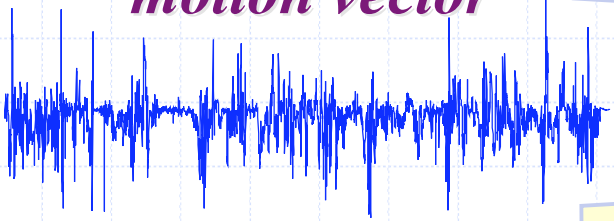
Overview

real image

viewing

extraction

motion vector

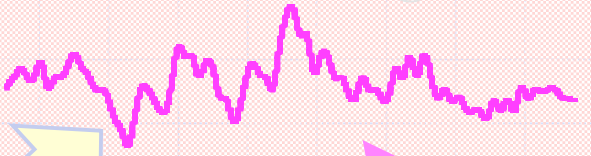


synthesis

random dot image by CG

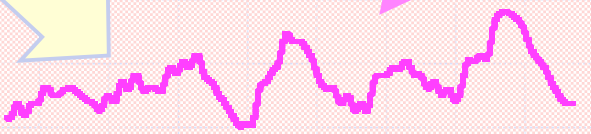
viewing

biosignal



correlation

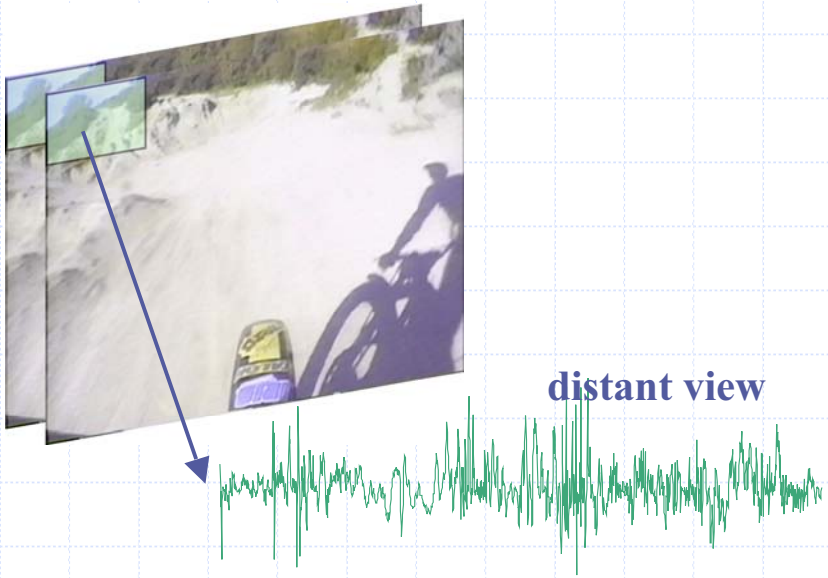
correlation



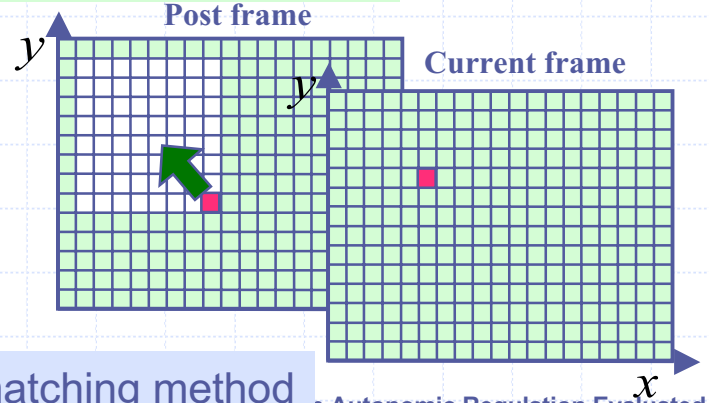
biosignal

Quantization of Image by Motion Vector

Local Motion Vector

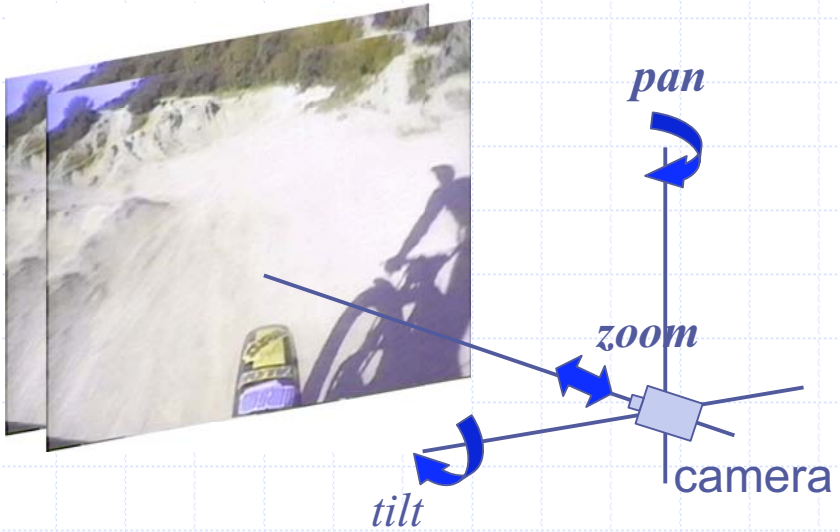


local motion in a screen

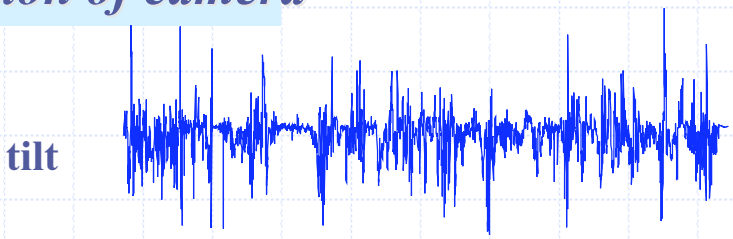


Block matching method

Global Motion Vector



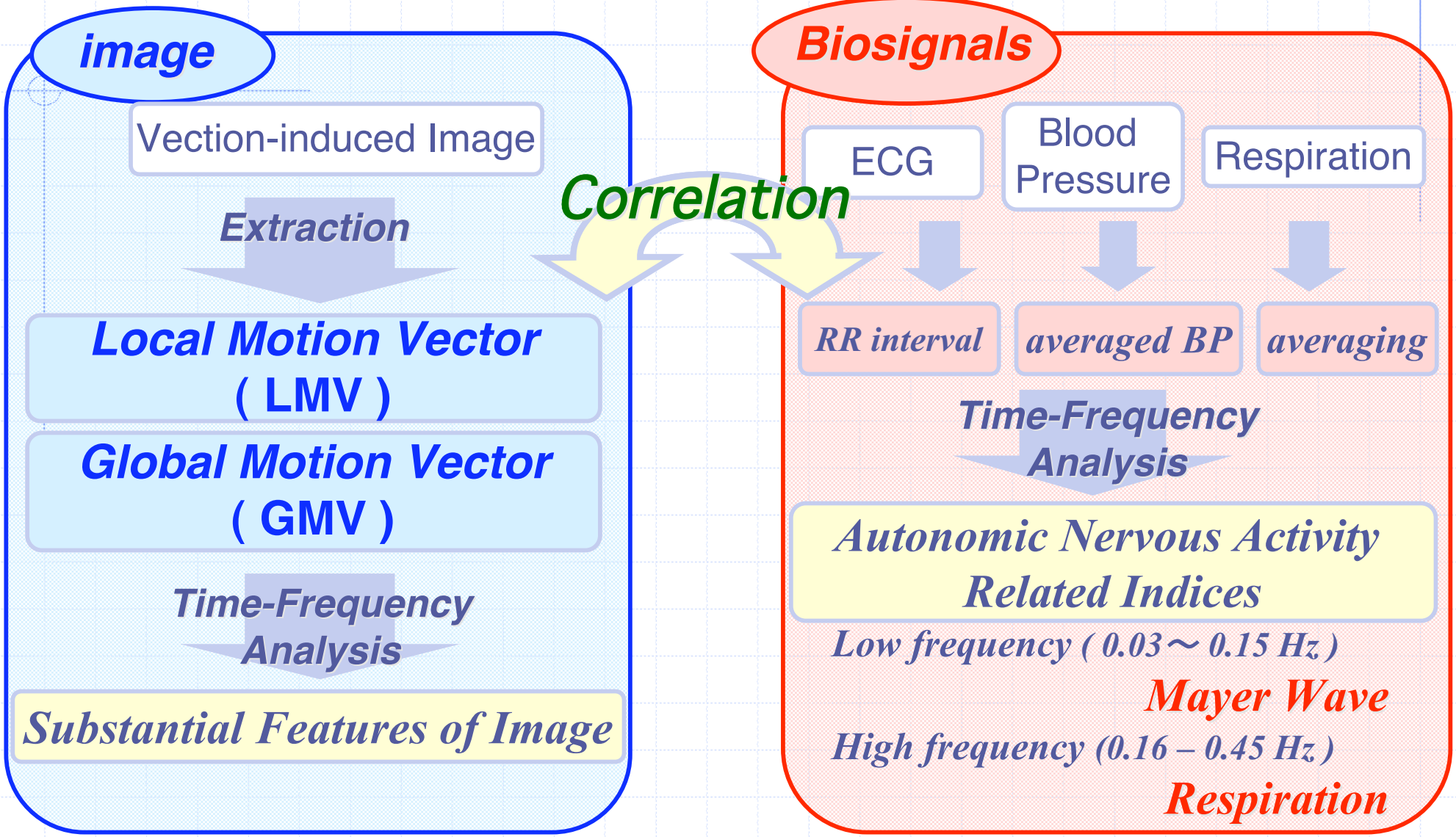
motion of camera



Bottom up approach

秦泉寺久美ら，“スプライト生成のためのグローバルモーション算出法と符号化への適用”，電子情報通信学会和文論文誌D-II, J83-D-II, 2: 535-544, 2000.

Signal Processing



Experiments under Real Images

real images

Parachute

Bobsleigh

boat

Go cart

Hang glider

Mountain-bike

Car race

Bungee jump

diving

Bike race

Vehicle experiencing video

subjects

1st Experiment: Five healthy elderly subjects (from 52 to 71 yrs. old) and six elderly subjects with mild hypertension or diabetes mellitus (5 males and 1 female from 50 to 71 yrs. old) .
2nd Experiment: ten healthy young subjects (8 males and two female from 21 to 24 yrs. old)

Measured Biosignals

ECG: chest

Respiration: tube sensors around the chest and the abdomen

Blood Pressure: tonometry method

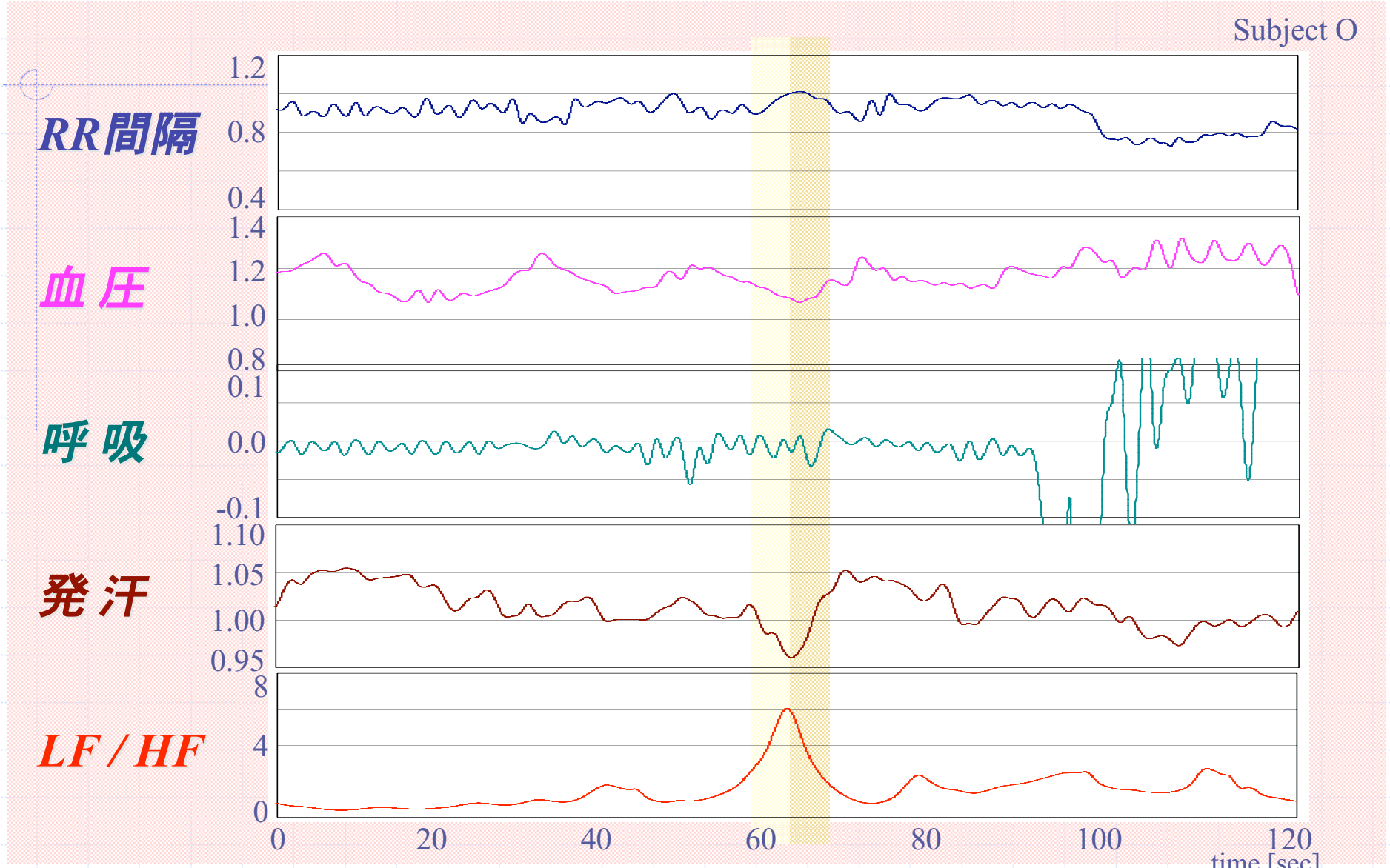
Blood flow: Laser Doppler at thumb sphere of left hand

Perspiration: Capsule type sensor at thumb sphere of left hand

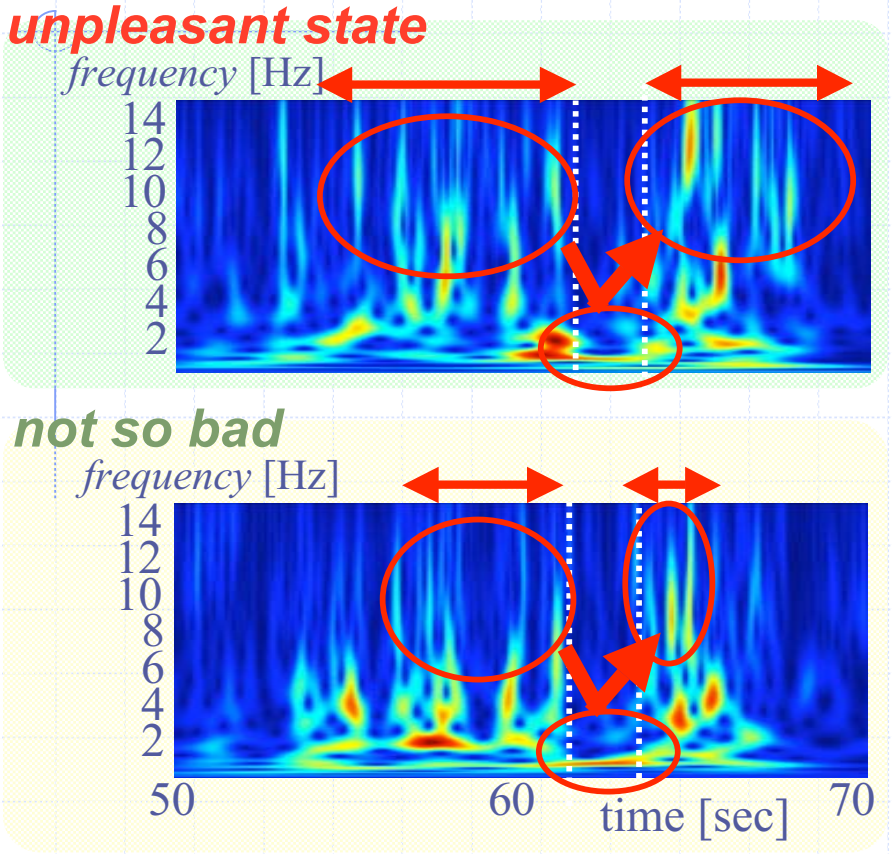
at Niigata University （Nov. 13, 14, 1999, Jan. 19, 21, Mar. 17, 2000）

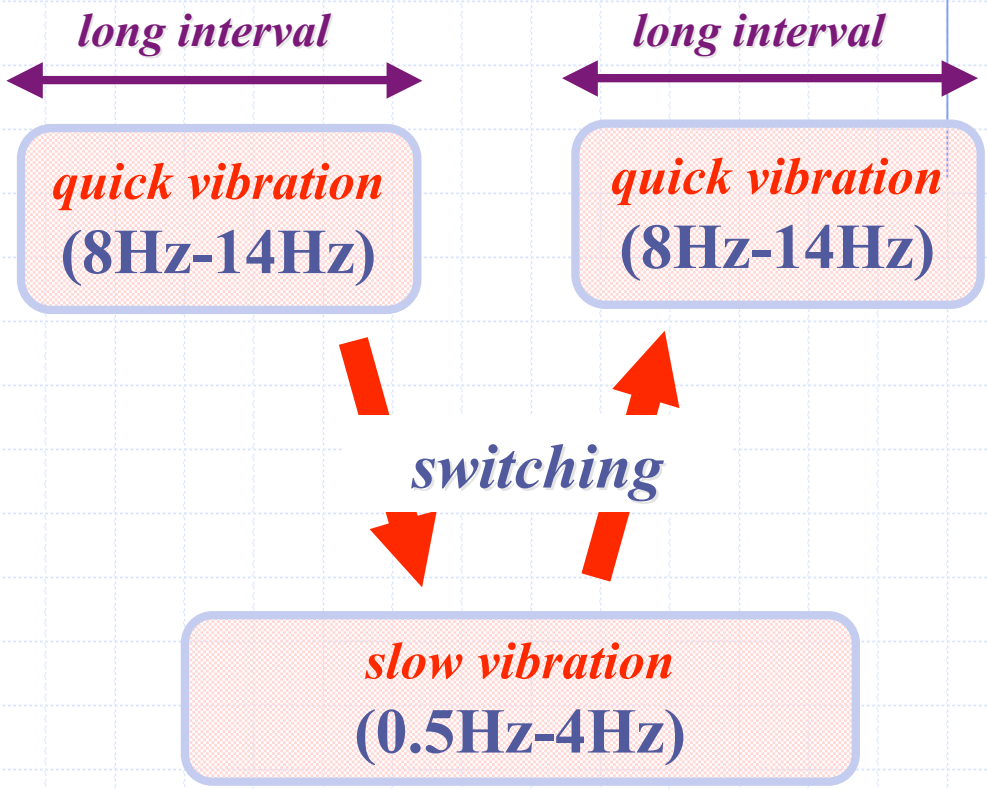
生体信号

マウンテンバイク映像視聴時



Time-varying Behavior of Motion Vectors in Unpleasant State（不快な場面での動きベクトル）

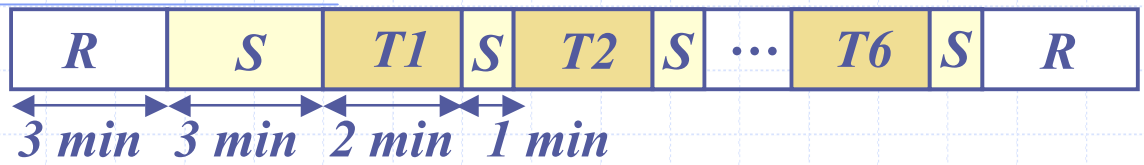




- *quick vibration of motion vectors possibly affect on autonomic regulations*
- *switching of frequency ranges and their elapsed time interval*

Searching Candidates from Components of Motion Vectors（動きベクトルの要素を探る）

Experimental Protocol



R : rest　　*S* : still picture　*T* : test under conditioned image

Subjects

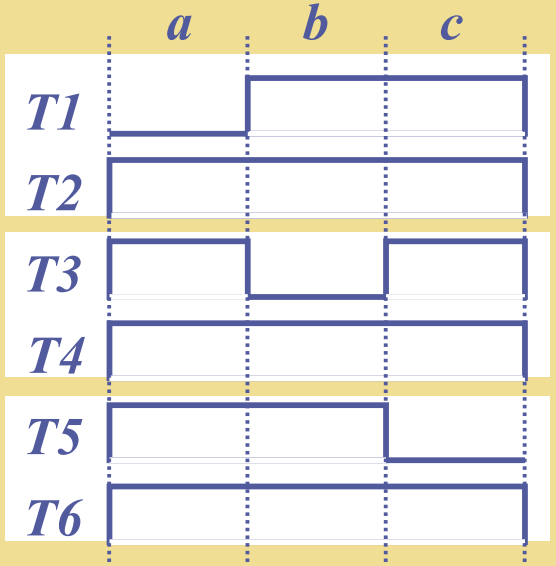
ten healthy young subjects (8 males and two female from 21 to 24 yrs. old)

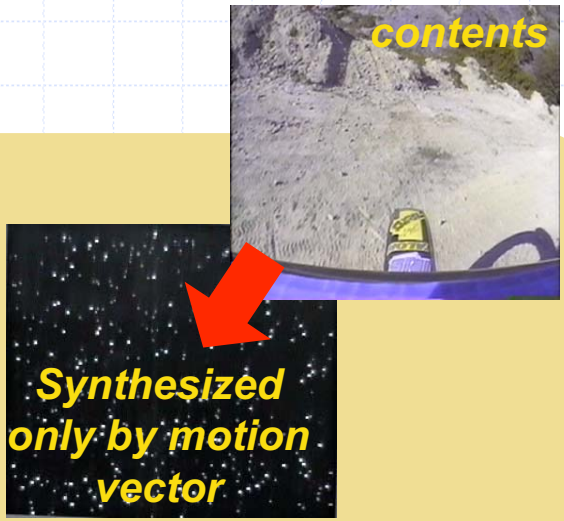
random dot pattern synthesized by CG

based on motion vectors from real mountain bike image

Comparison between

1. *GMV and LMV*
2. *among GMV parameters*
3. *among LMV parameters*
4. *among frequencies*
5. *among frequencies for switching*





a : zoom
b : pan
c : tilt

at Niigata University on Dec. 1-22, 2002.

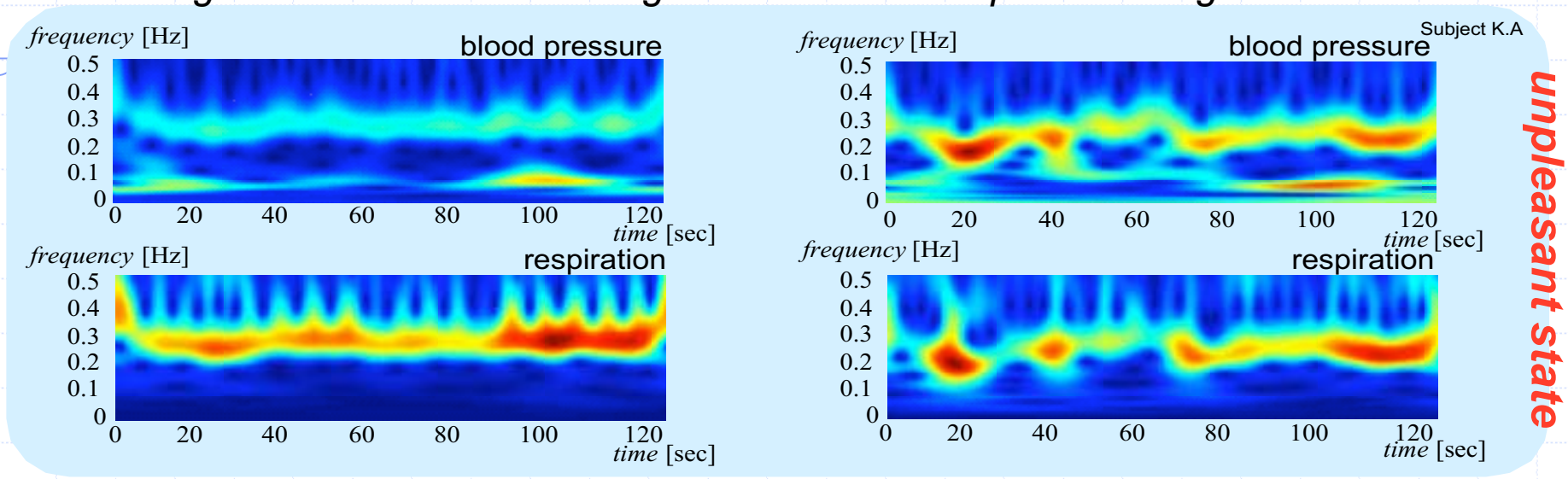
TFRs of Biosignals under Real and CG images

Real image of mountain-bike riding

Random dot pattern image based on real image

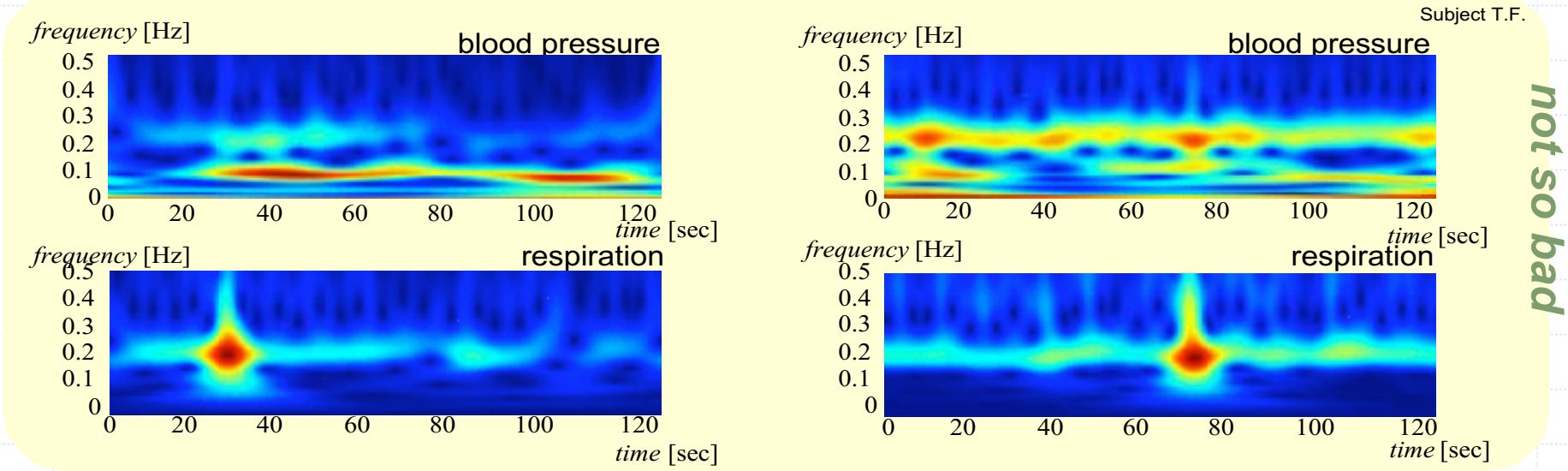
not so bad

unpleasant state



unpleasant state

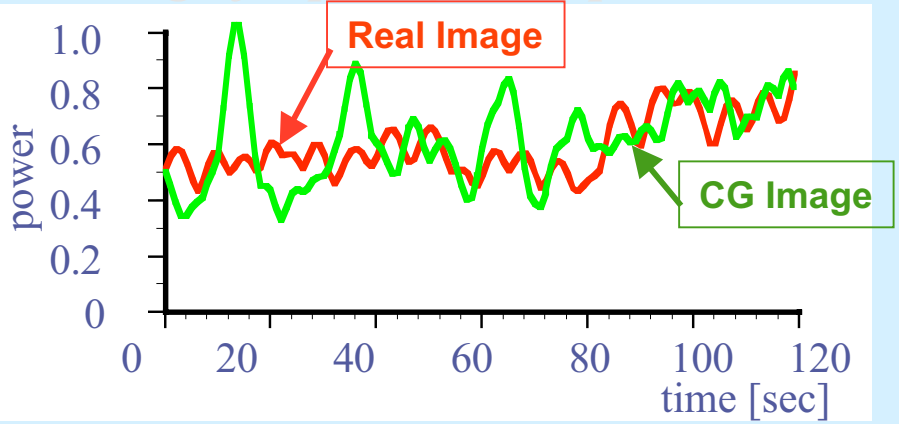
not so bad



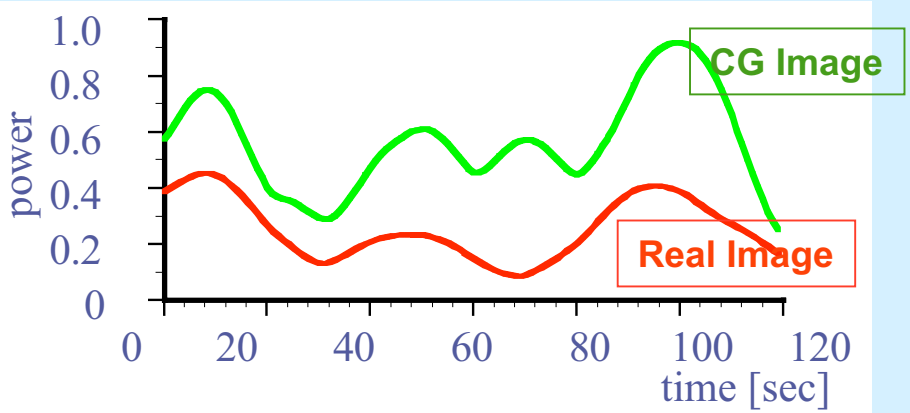
HF and LF Components of Biosignals

low frequency : 0.03 – 0.15 Hz
high frequency : 0.16 – 0.45 Hz

high frequency in respiration



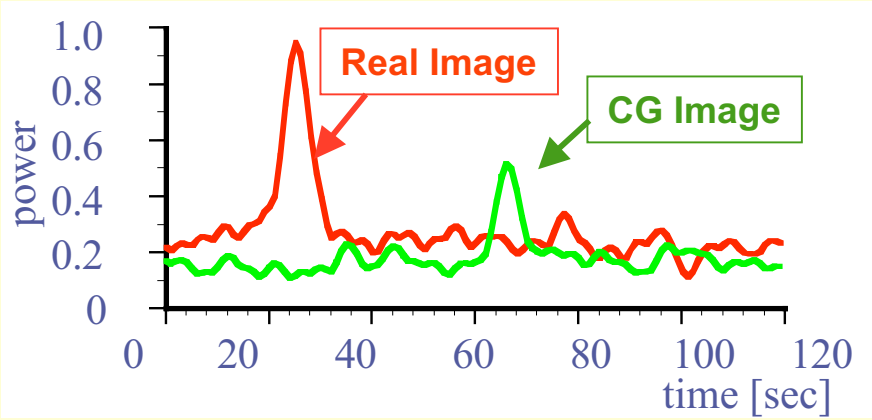
low frequency in blood pressure



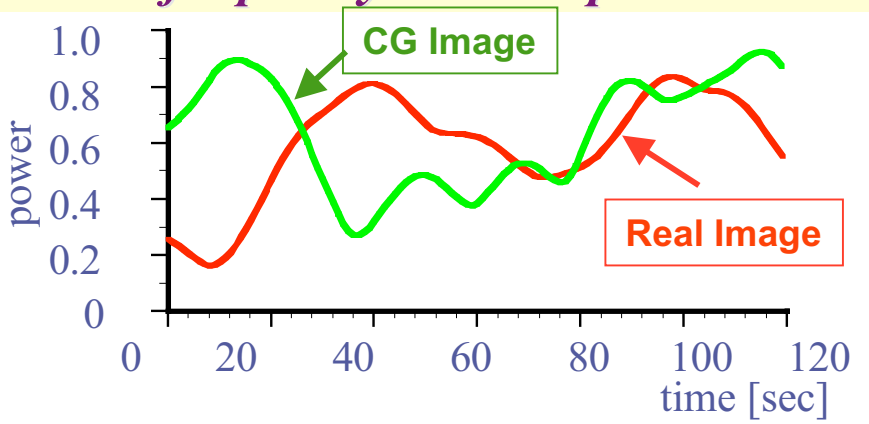
unpleasant state appeared for CG image

Subject KA

high frequency in respiration



low frequency in blood pressure



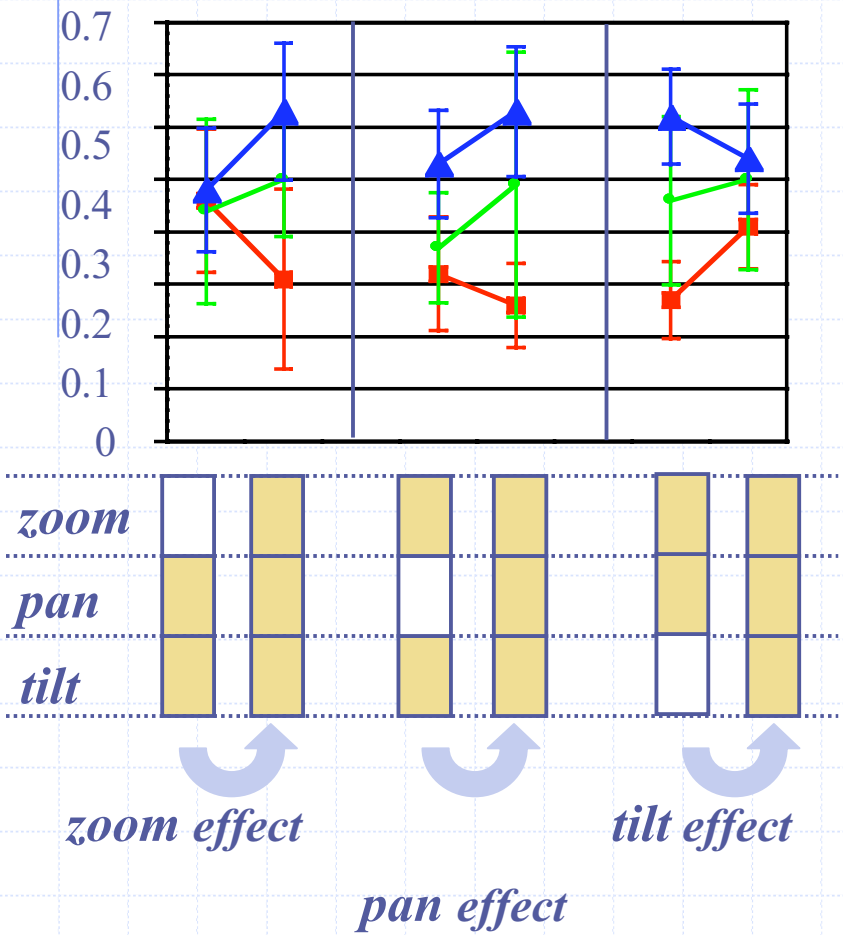
unpleasant state appeared for real image

Subject TF

Changes in Autonomic Indices affected by Components of Motion Vectors

LF/HF
LF : power of low frequency (blood pressure)
HF : power of high frequency (respiration)

low frequency : 0.03 – 0.15 Hz
high frequency : 0.16 – 0.45 Hz



ズームとパンは交感神経に影響

Adding zoom- and pan-components caused decrease of HF, increase of LF and LF/HF.

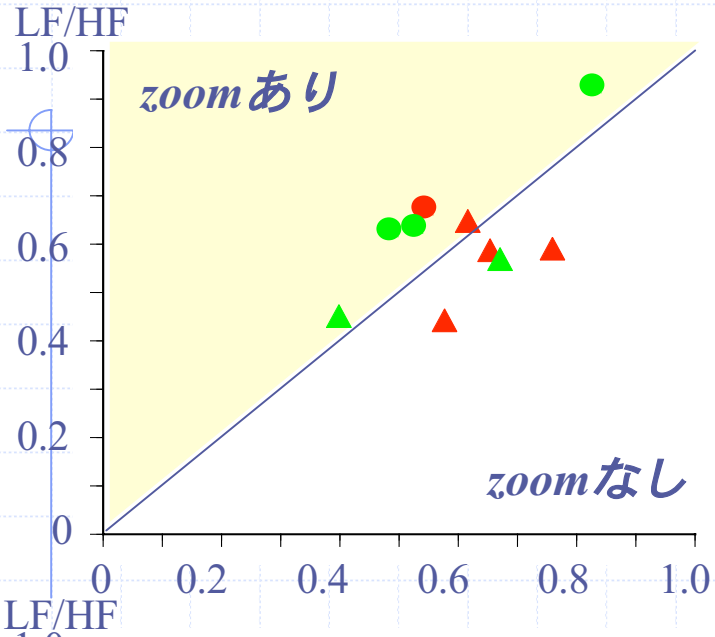
→ degeneration of parasympathetic nerve activity and enlargement of sympathetic nerve activity

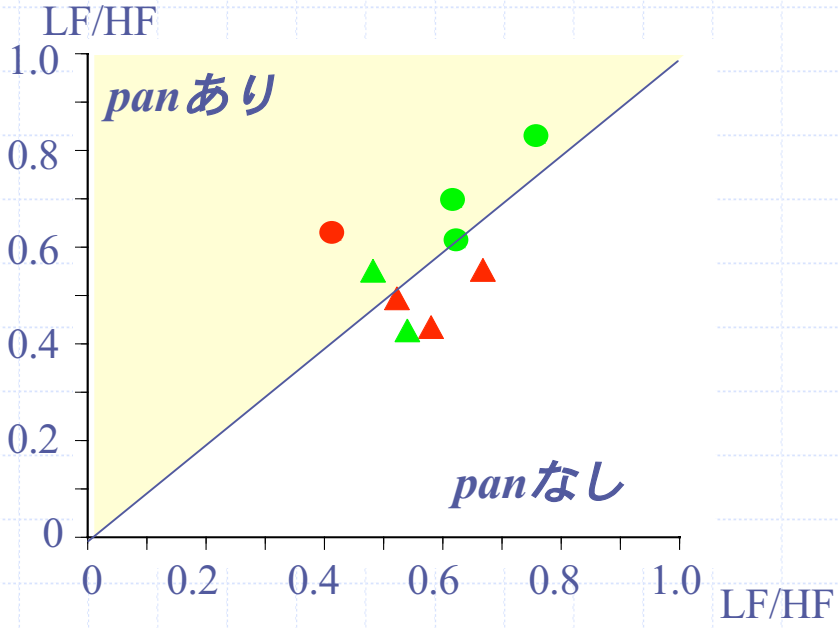
チルトは副交感神経に影響

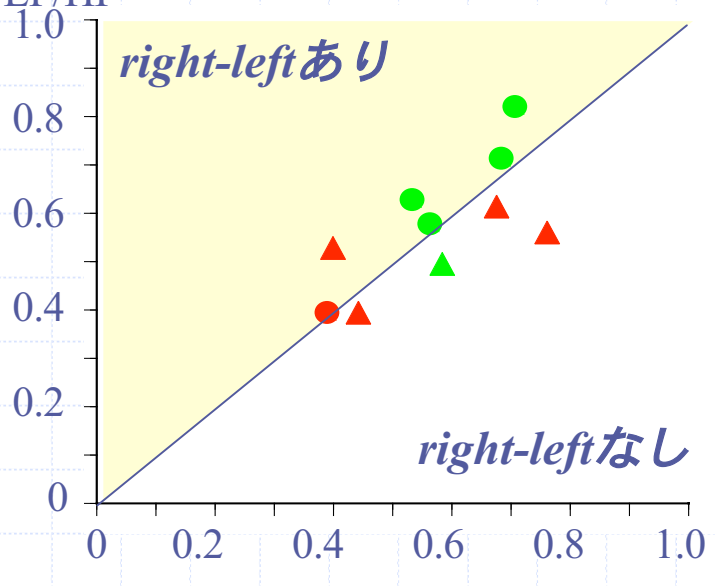
Adding tilt-component caused increase of HF and LF, and decrease of LF/HF.

→ degeneration of sympathetic nerve activity and enlargement of parasympathetic nerve activity

生体に影響を与える動きベクトルの要素







●マウンテンバイクが気持ち悪い人
▲同上（HF成分が増加）

●マウンテンバイクが気持ち悪くない人
▲同上（HF成分が増加）

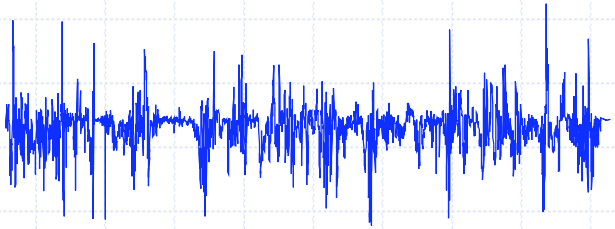
ランダムドットによるシミュレーション映像

Discussion（実写とCGの違い）
– Differences between Real and CG Images –

Real Image

able to predict

same motion vector



視覚系と前庭系

CG Image

unable to predict

Effect of Image Contents

- *psychological element*
- *prediction based on experience*
- *prediction based on spatial*

acknowledgment *of real environment*

実写映像のコンテンツが予測を
助けている

Visual & Vestibular info.

不調和

miss match

prediction
予測

accumulation
蓄積

Disturbance of Autonomic Regulations
自律神経系への外乱

Discussion（実写とCGの違い）

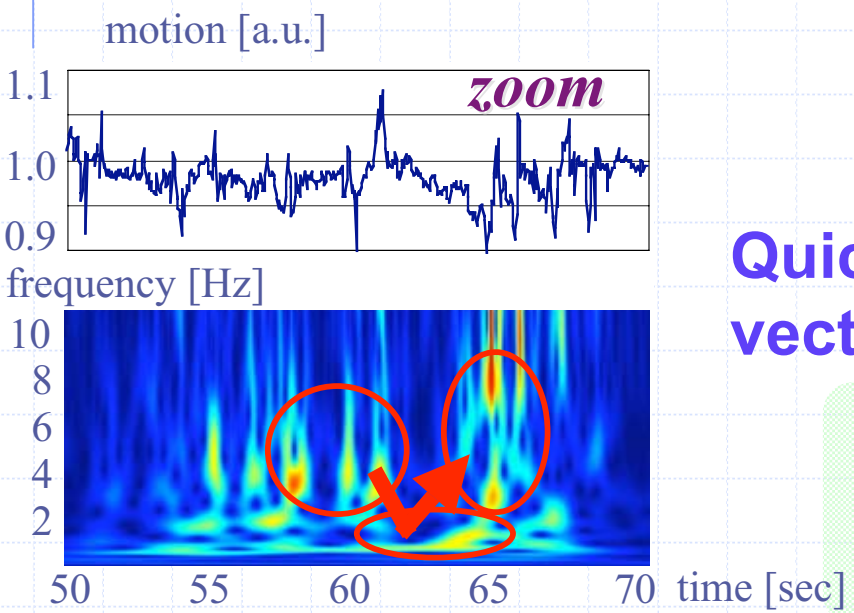
– Prediction of Traveling direction by and Motion Vector –

Zoom component affected on autonomic regulations, referring to the experimental results.

ズームが自律神経系に影響を与えていた

ズームを予測に使用しているのではないか.

zoom component might be used for prediction of traveling direction



Quick vibration appeared in motion vector could disturb prediction

動きベクトルの周波数の急激な変化→
予測に反する動き