

A strange effect of physics

Synchronization of **metronomes**

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1 Background and Objective

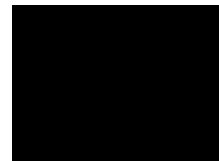
Synchronization around us is confirmed just as a physical phenomenon but its principle is not clear.

We are trying to analyze it.

1 Background and Objective

For example...

池口研究室
 ろうそく同期 (2本)
 Synchronization of two candles
 2009年7月22日、池口研究室にて撮影
 Filmed at Ikeguchi Laboratory, on July 22, 2009.



3 Experiment



3 Progress



Analyze the experiment

Demonstrate by mathematics and Simulate on the computer



$$\begin{aligned}
 & (m_1 \ddot{\theta}_1 + M_1 L_1 \ddot{\theta}_1) + (M_1 L_1 - m_1 g) \sin \theta_1 = -g (M_1 L_1 - m_1 g) \sin \theta_1 + F_{12} + F_{13} \\
 & (m_2 \ddot{\theta}_2 + M_2 L_2 \ddot{\theta}_2) + (M_2 L_2 - m_2 g) \sin \theta_2 = -g (M_2 L_2 - m_2 g) \sin \theta_2 + F_{21} + F_{23} \\
 & (m + M_1 + M_2 + M_3) \ddot{x} + (M_1 L_1 - m_1 g) \cos \theta_1 + (M_2 L_2 - m_2 g) \cos \theta_2 \\
 & - (M_1 L_1 - m_1 g) \dot{\theta}_1^2 \sin \theta_1 - (M_2 L_2 - m_2 g) \dot{\theta}_2^2 \sin \theta_2 = 0
 \end{aligned}$$

3 Progress (analyzing the experiment)

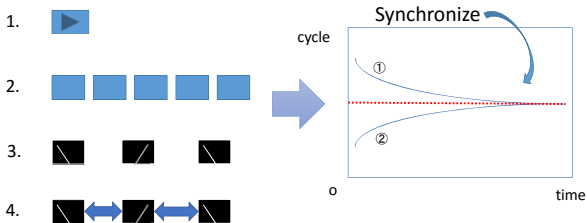
We are trying to make a program as follows

1. Divide the video of the experiment into the pictures of the frames
2. Binarize them and analyze the cycle of the metronomes
3. Examine the change of the cycle

3 Progress (analyzing the experiment)



3 Progress (analyzing the experiment)



3 Progress (analyzing the experiment)

We are making a program like this. It is incomplete yet.

```

from PIL import Image

def filter(col):
    if col>50: return 225
    else: return 0

in_img = Image.open('met_100.jpg').convert('L')
in_img = in_img.point(filter)
in_img.save('met2.jpg')
in_img.show('met2.jpg')
    
```

3 Progress (demonstration by mathematics)

F_s^* : force of the spring
 F_r : frictional force

$$\begin{aligned}
 (m_1 \ddot{\theta} + M_1 L_1 \dot{\theta} + (M_1 L_1 - m_1 g)) \dot{\theta} &= -g(M_1 L_1 - m_1 g) \sin \theta + F_{cs} + F_{rs} \\
 (m_2 \ddot{\theta} + M_2 L_2 \dot{\theta} + (M_2 L_2 - m_2 g)) \dot{\theta} &= -g(M_2 L_2 - m_2 g) \sin \theta + F_{cs} + F_{rs} \\
 (m_1 + M_1 + B + m_2 + M_2) \ddot{x} &+ (M_1 L_1 - m_1 g) \theta_1 \cos \theta_1 \\
 &- (M_2 L_2 - m_2 g) \theta_2 \cos \theta_2 - (M_1 L_1 - m_1 g) \theta_1^2 \sin \theta_1 \\
 &= 0
 \end{aligned}$$

4 Future Work

- Compare the results of analysis and demonstration
- Try other synchronizations
- Test Lagrange for this over other synchronizations

References

龍谷大学工学部数理情報学科2012年度卒業論文
“メトロノームは本当に同期するのか”

三崎洋平

指導教員 池田勉

My teammates

Taishi Kumagai, Soudai Tanaka, Syunji Hagimori, Souma
Hattori, Kazunari Yamakawa

Question 1

• What is the name of the equation we used?

- a) Lagrange equation
- b) Laglarge equation
- c) Lagrarge equation
- d) Laglange equation

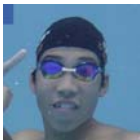
Question 2

• Which is Soudai Tanaka(one of my teammates)?

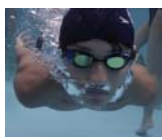
a)



b)



c)



d)

