



pH detection using methyl red and RGB based regression modeling

1. Introduction

DSHS group tried to predict pH using RGB-pH quadratic polynomial regression. The result was generally successful. However, they had some errors and assumed the cause was variation in brightness and angle. Thus, we conducted a similar experiment using methyl red(MR) under arranged conditions.

2. Purpose

Get RGB-pH quadratic polynomial regression equation which can predict pH from a solution colored by MR.

3. Research methods

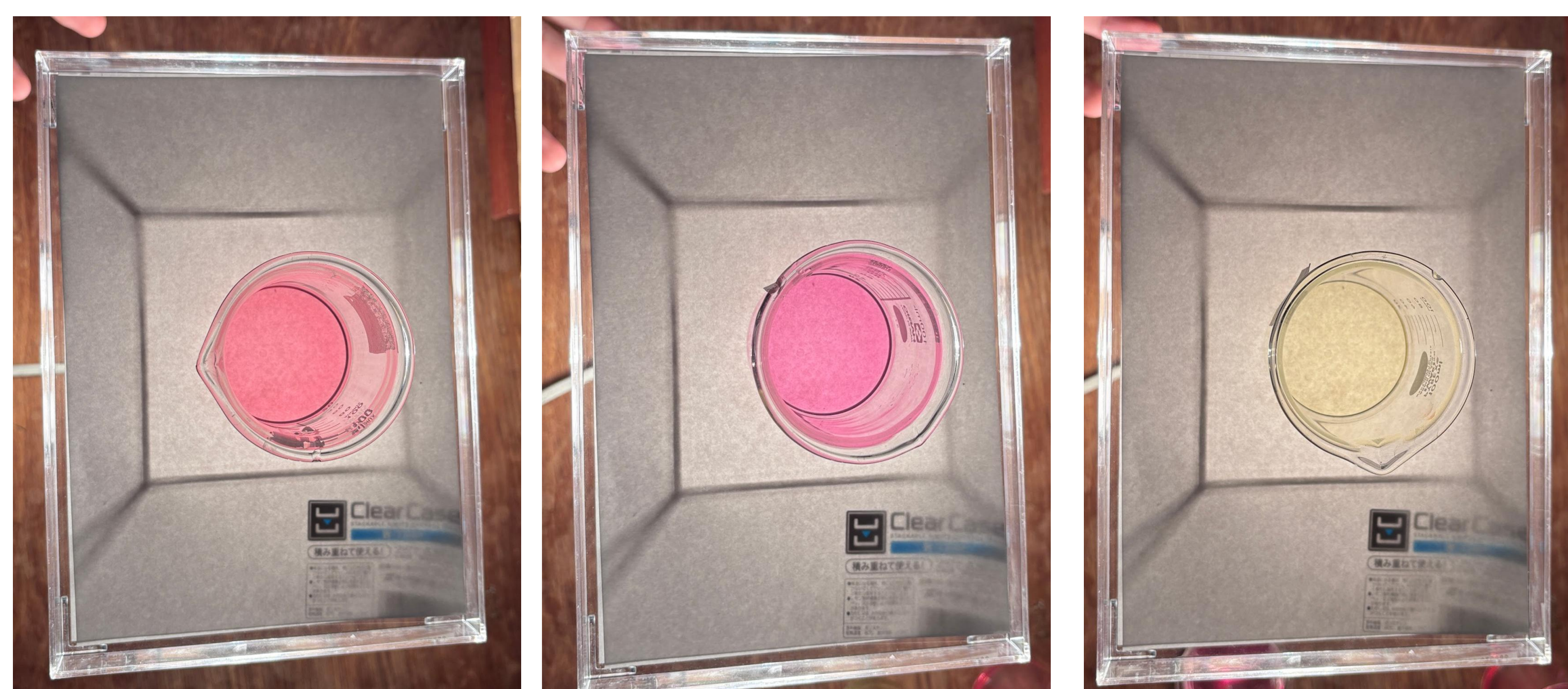
Prepare 20 ml of buffer solutions with different pH values.

(pH1.97,4.22,7.01) Add two drops of MR to each solution. Take picture of solutions illuminated from below in a dark room.

(picture 1)

Create a program which record the RGB values of each of the 100 points taken from the solution area in the photograph, and get RGB-pH quadratic polynomial regression.

Finally, evaluate the accuracy of the regression equation by using a pH5.09 solution.



pH1.97

pH4.22

pH7.01

4. Results

We were able to get an approximate expression to find pH values from RGB.

$$\text{pH}_{\text{predict}} = -20.887811 + 0.219854 * R + 0.262040 * G - 0.255979 * B - 0.000959 * R^2 - 0.002934 * R * G + 0.003885 * R * B + 0.001804 * G^2 - 0.001055 * G * B - 0.001245 * B^2$$

Also, substitute RGB values which pH became 5.09, but we couldn't get appropriate results.

新しいRGB [230 143 149] (R=230, G=143, B=149) に対する予測pH: 1.70

Predicted pH values for RGB values when pH is 5.09

5. Discussion

About the poor accuracy of prediction, we assume it is because the number of data was small, MR has a strange property, the metric of RGB cannot reflect all spectral characteristics of MR, or quadratic model may not fit the features of pH. As methods to solve these problems, we can gather more pH data, use another indicator(i.e. Universal Indicator, BTB), apply another color model, or analyze the spectrum.

6. Conclusion

In this way, it seemed to be difficult to get the RGB-pH equation, while improving the method of experiment may make the equation better.

7. Acknowledgement

We would like to appreciate Morita Sensei, Ishikawa Sensei, and Kataizah Sensei for a lot of encouragement and advice.



picture 1: Device for experiment



Charge-Modified Eggshell Adsorbent for Enhanced PFAS Removal

1. Research introduction

Our group tried to eliminate PFAS, which are considered “forever chemicals”, by using powdered eggshells. Once charged the eggshells become able to absorb PFAS, which become an anion in the water. Thus, we conducted a similar experiment using methyl orange(MO) in place of PFAS under the following experimental conditions.

2. Purpose

Prove that the ionized eggshells tend to absorb more MO than non-ionized eggshells.

3. Research methods

Step 1: Eggshell Preparation

- Wash, dry (125°C), grind, and sieve (100–200 μm).

Step 2: TENG Charging

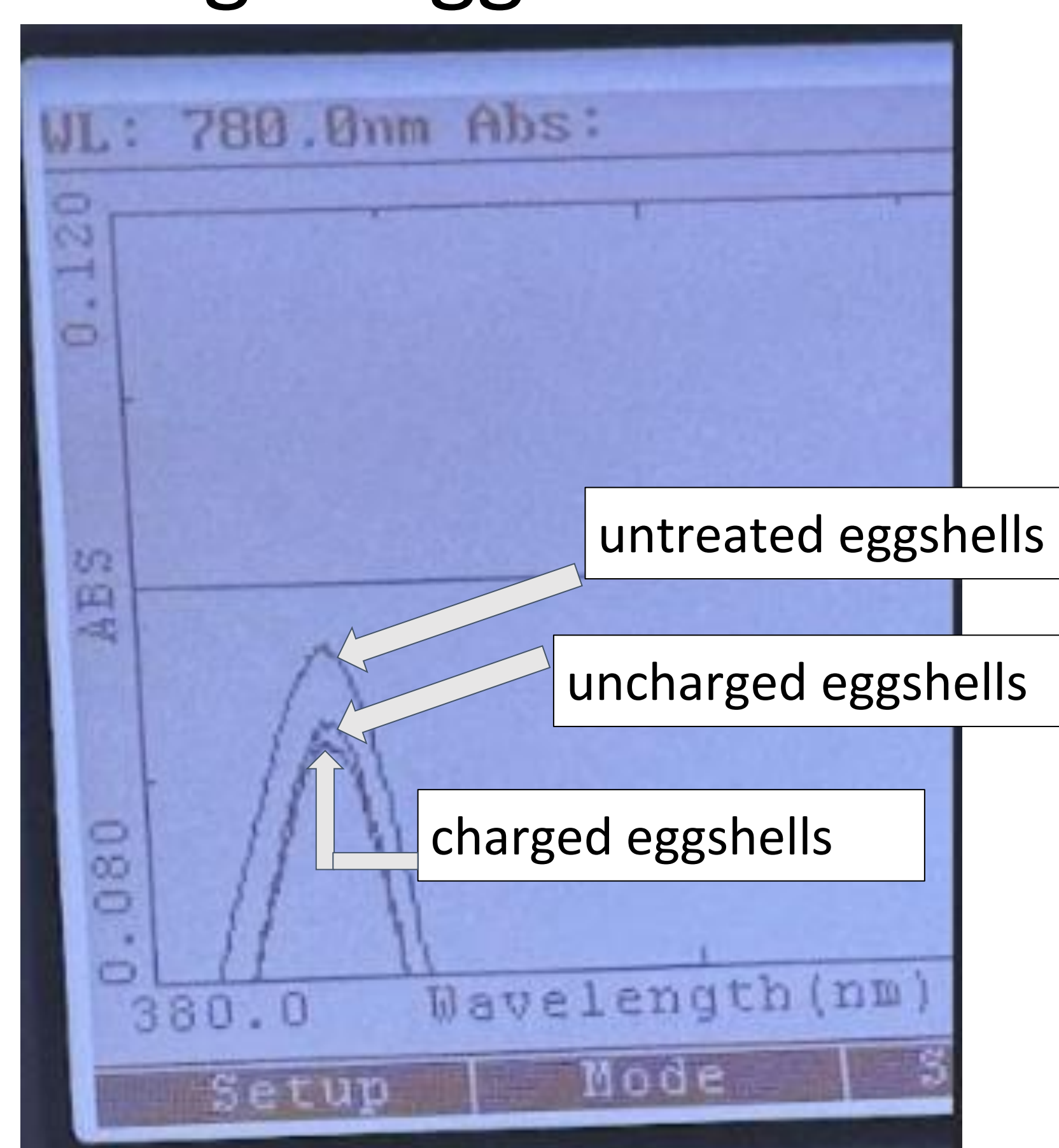
- Place the eggshell powder on an aluminum surface.
- apply charge by repeatedly contacting and separating it with a plastic sheet.

Step 3: Adsorption Procedure

- Prepare three 100ml of MO aqueous solution (3000 ppm).
- Add 0.5g of powder (charged or uncharged).
- Stir for 60 minutes at 150 rpm.
- Filter and measure absorbance (UV-Vis, from 380 to 700 nm).

4.Result

The image shows that untreated MO indicated highest absorbance, but there is little difference between charged and uncharged eggshells.



4. Discussion

It has been confirmed that eggshells absorb methyl orange to some extent. However, there was little difference between charged and uncharged eggshells. That is likely because 3 possible reasons.

The charging effect was not strong enough to influence adsorption. The charge may have been lost during stirring or due to environmental factors such as humidity.

It is also possible that the natural adsorption ability of eggshells overweight and masked the effect of the added charge.

5.Conclusion

Charging did not clearly improve adsorption, but eggshells still show potential as an adsorbent for future optimization.



Effects of Drop Height, Paper Type, and Ink Viscosity on Ink Bleeding

1. Purpose

After we listened to the research of Daejeon Science High School, we thought we should try to evaluate bleeding by changing two conditions; drop height of the ink and type of paper. In addition, we think we can evaluate the bleeding from ink bleeding area and number of sheets of paper.

2. Previous Research

Past research shows that spreading area of ink: print paper > Hanji
They reported this difference may have been because Hanji has shorter fibers. They researched bleed reactions by measuring ink bleeding area and contact angle.

3. Hypothesis

Hypothesis 1: Height \uparrow \Rightarrow Spreading \uparrow

Hypothesis 2: for bleed area,

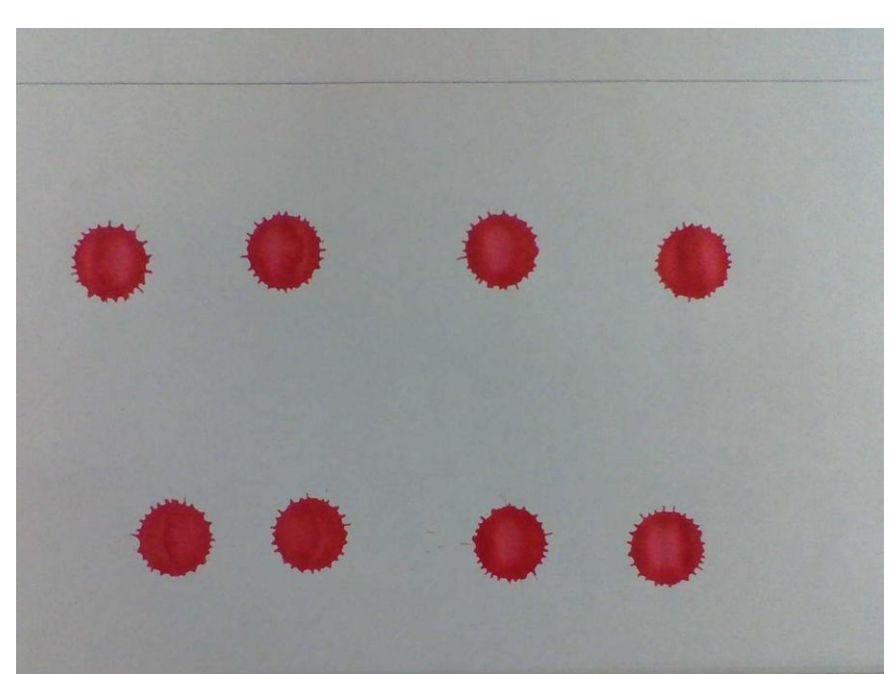
Washi > print paper

Hypothesis 3: Viscosity \uparrow \Rightarrow Spreading \downarrow

4. Experimental material

- print paper, Washi
- plastic burette
- ink (Fantasy red, used as flower dye)
- wireless drop counter
- ImageJ

\downarrow print paper



plastic burette \rightarrow



5. Experimental method

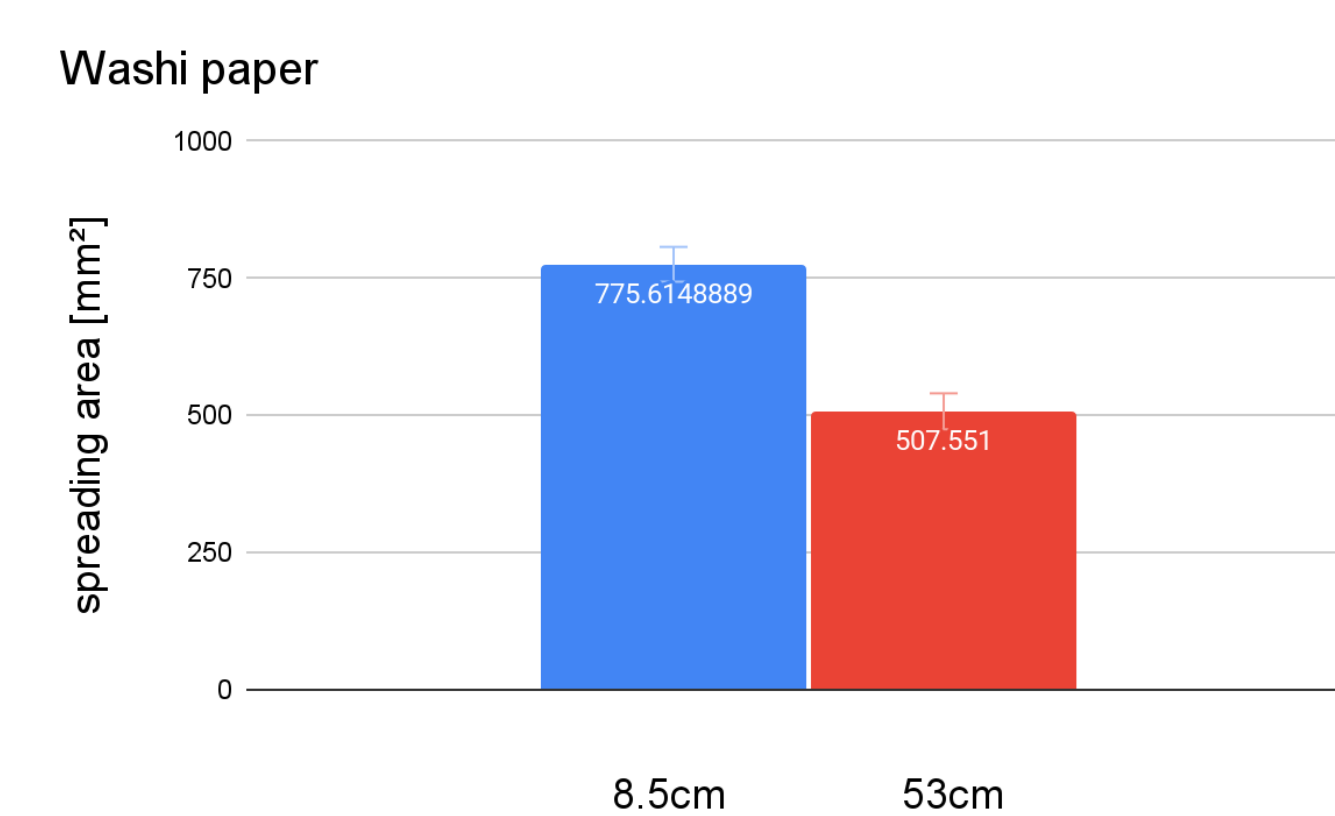
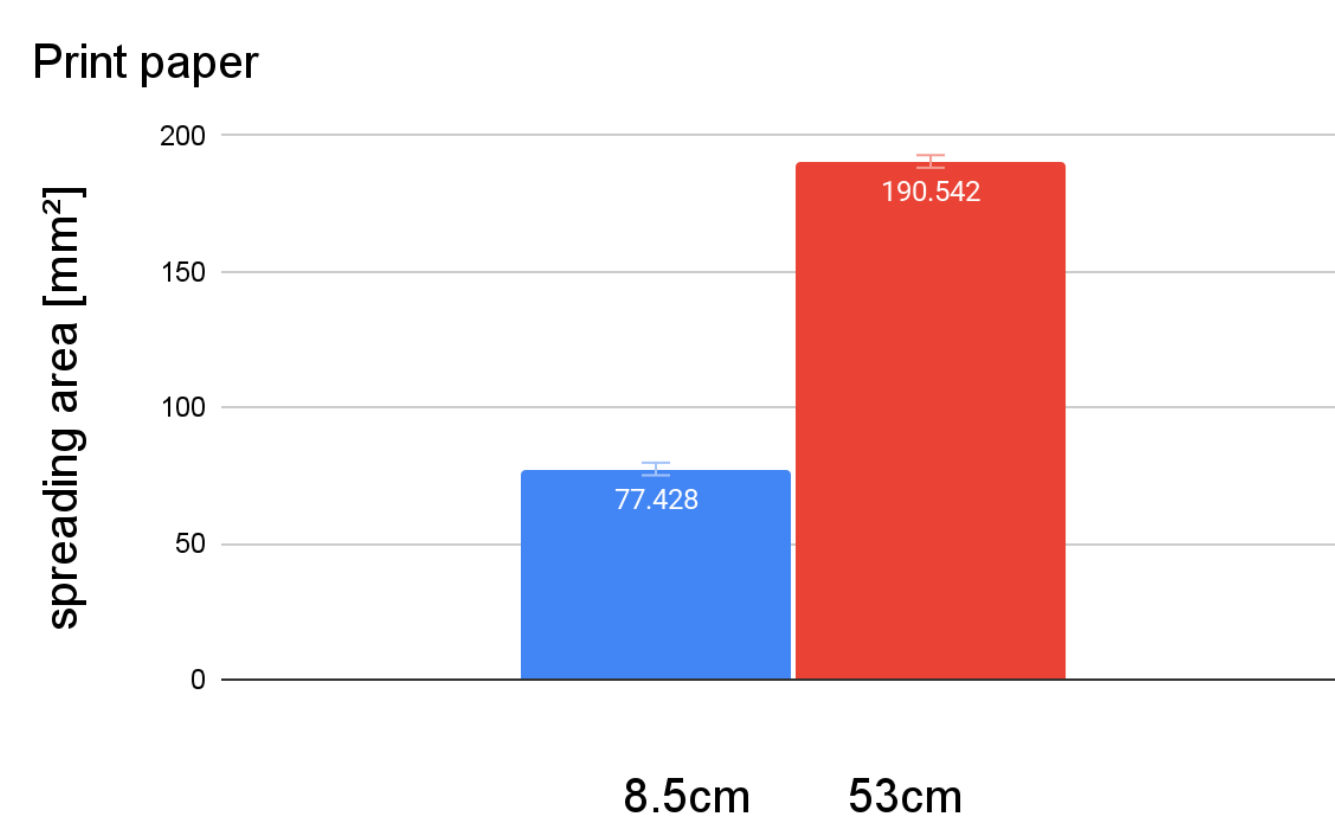
Experiment 1: Changing the drop height of ink (8.50cm or 53.0cm)

Experiment 2: print paper vs Washi

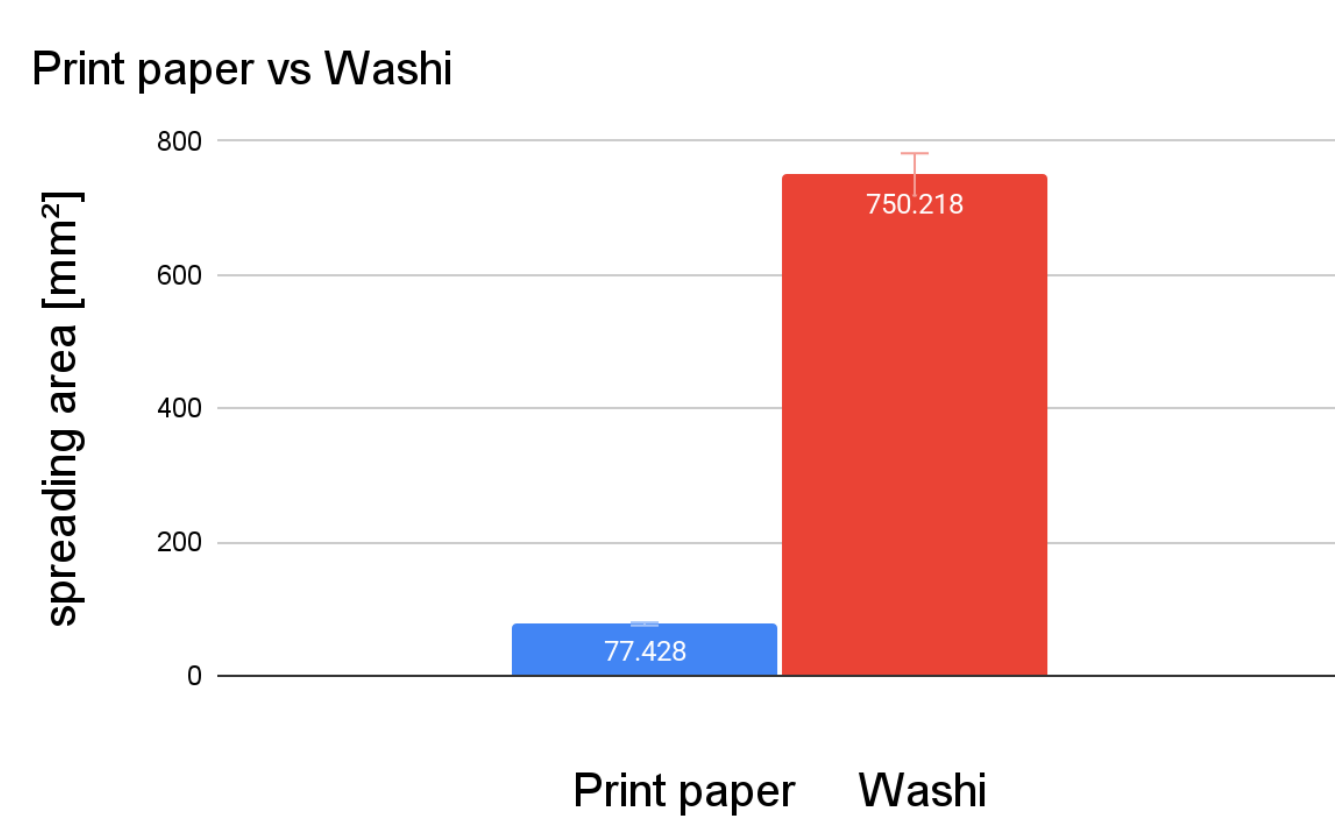
Experiment 3: Changing the viscosity of ink
We added glycerin to ink to final concentration of 10%

6. Results

Experiment 1:



Experiment 2:



Experiment 3:

Print paper		
	Spreading area[mm ²]	Number of sheets of paper
ink	190.54	1
ink + glycerin	188.6	1
Washi		
	Spreading area[mm ²]	Number of sheets of paper
ink	507.55	3
ink + glycerin	675.22	1

7. Discussions

• Print paper: Height \uparrow \Rightarrow Pressure \uparrow
 \Rightarrow Spreading \uparrow

Washi: Height \uparrow

\Rightarrow The vertical spreading of the ink \uparrow
 \Rightarrow Spreading \downarrow

• Washi has long fibers, so its spreading area was larger than that of print paper

• Viscosity \uparrow

\Rightarrow The vertical spreading of the ink \downarrow

8. Conclusions

• There was no clear relationship between the height the ink was dropped from and how easily it bled.

• for bleed area, Washi > print paper.

• The horizontal spread into the paper was the same whether the viscosity of ink was high or not, while the vertical spread was smaller when the viscosity of the ink was high.

9. References

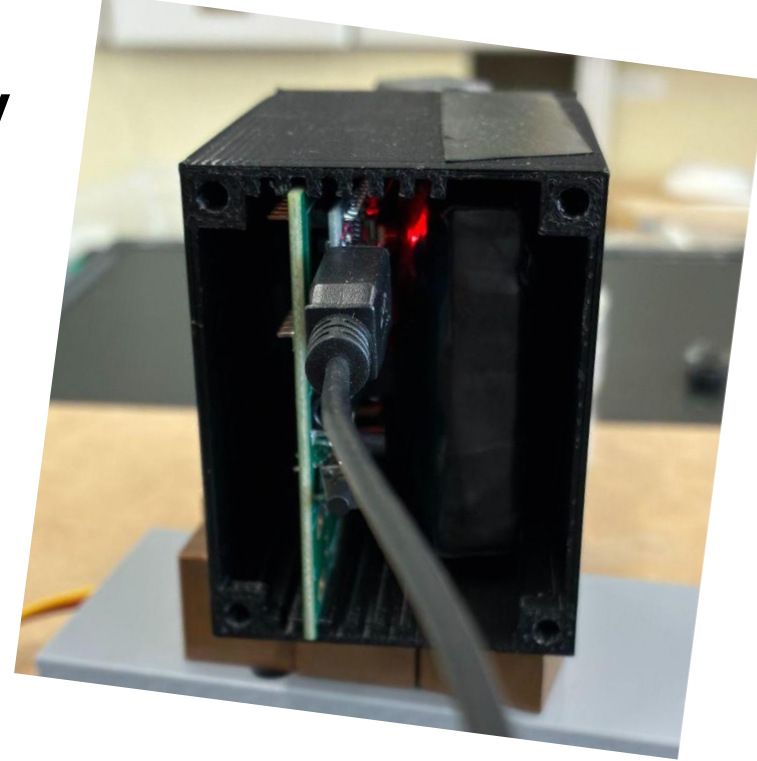
“A Study on Bleed Reduction of Hanji-Compatible Ink Using Eco-Friendly Surfactant Lecithin”, Daejeon Science High School, team C



Measurement of Material Distribution Using Monazite

Background

We were inspired by last year's Cosmic Ray Exploration Program, where we learned how easily Cosmic Watch can measure cosmic rays. This led us to try a radiation experiment in our school laboratory.

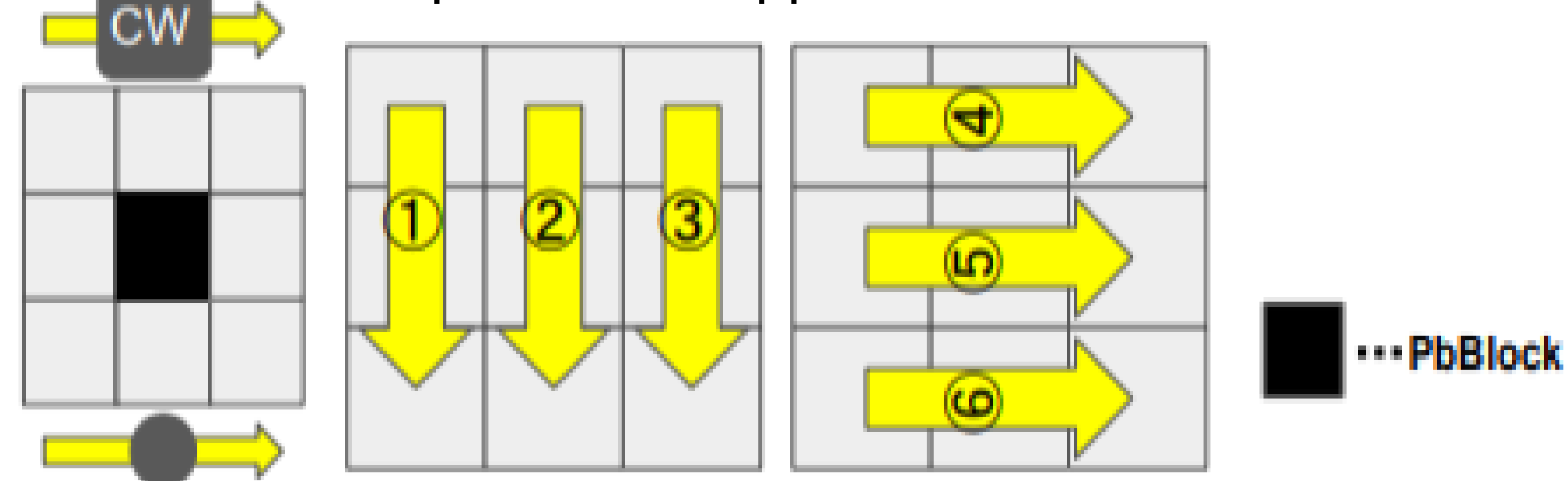


Previous Research

Akita High School used monazite to find lead blocks in a 3x3 grid. Monazite is a natural radioactive mineral.

However, their method makes some errors, and sometimes failed when several blocks were used.

We aimed to improve their approach.



Purpose

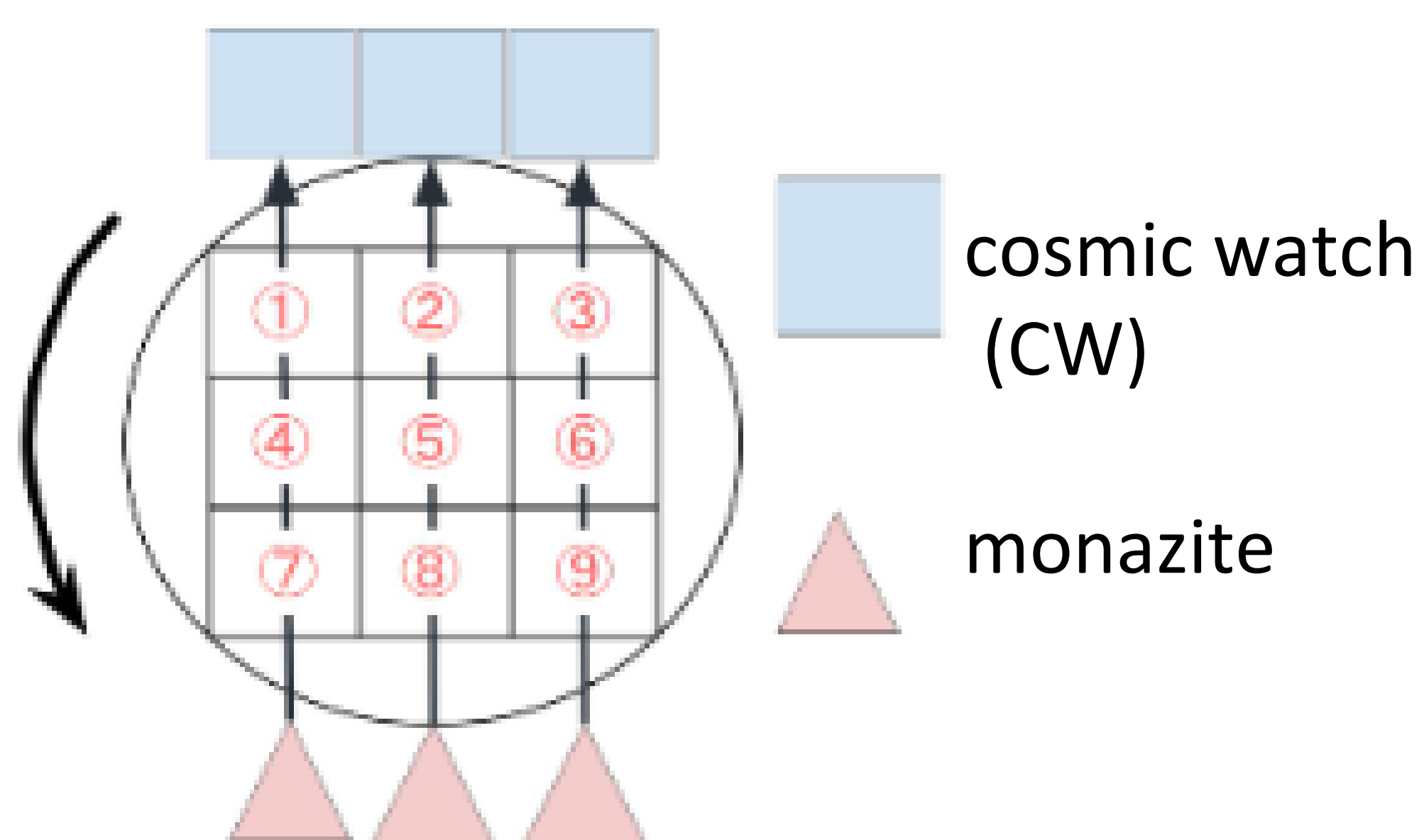
Our purpose is to estimate which cell of a 3x3 grid contains lead blocks, by using the fact that radiation from monazite becomes weaker when it passes through shielding material.

Method

Monazite and the detector were placed facing each other with a 3x3 grid in between.

The grid was rotated from 0° to 180° in 15° increment.

We measured count rates for 10 minutes at each angle and used three detector positions.



Analysis

We calculated attenuation coefficients for each cell using Python.

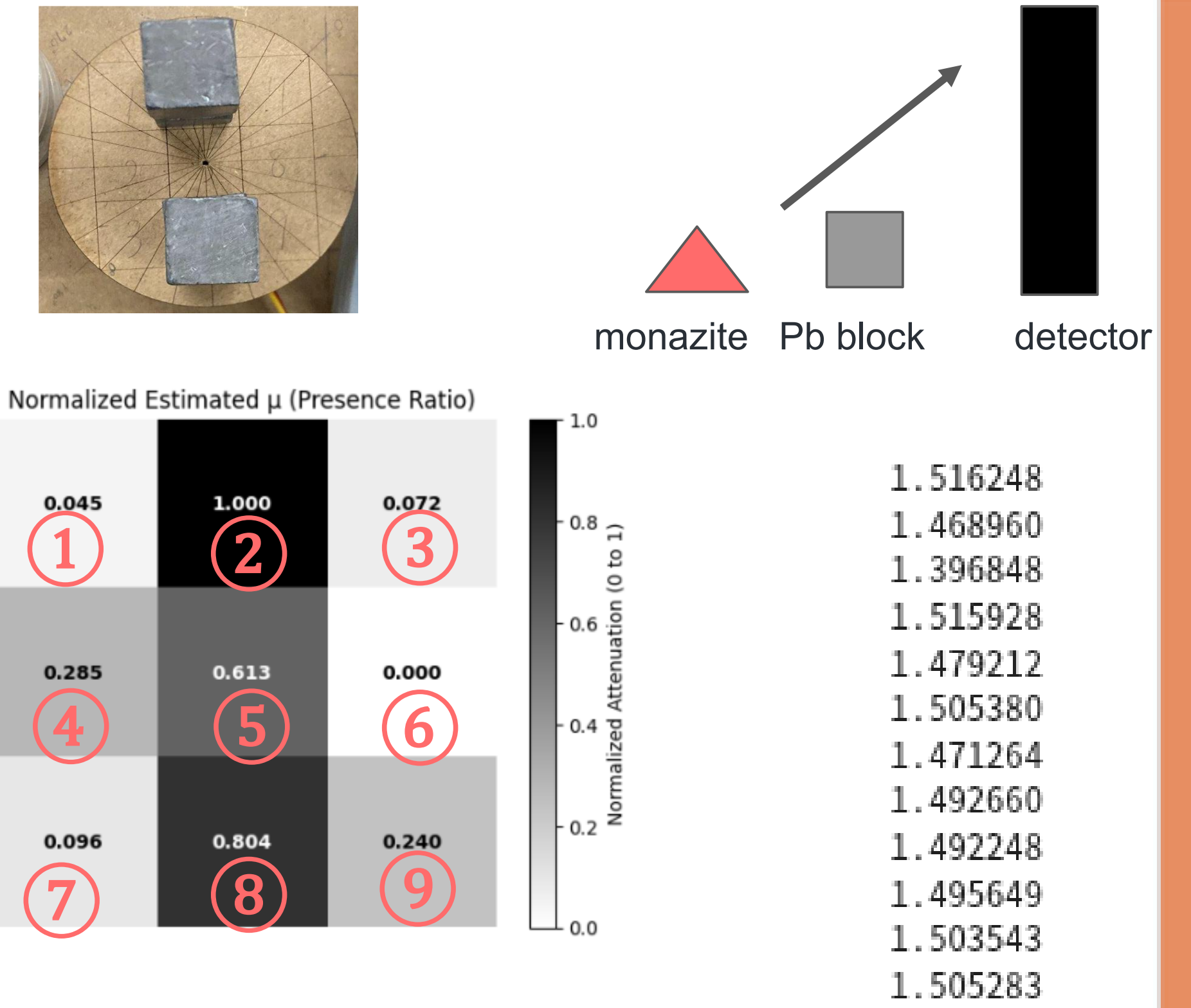
The values were normalized (0–1) to create an image.

Rotation gave CT-like multi-directional data.

Improvements

Background noise was large, and lead did not block enough radiation.

We increased the amount of monazite from 1 to 5 pieces and made the lead blocks 3 layers tall.

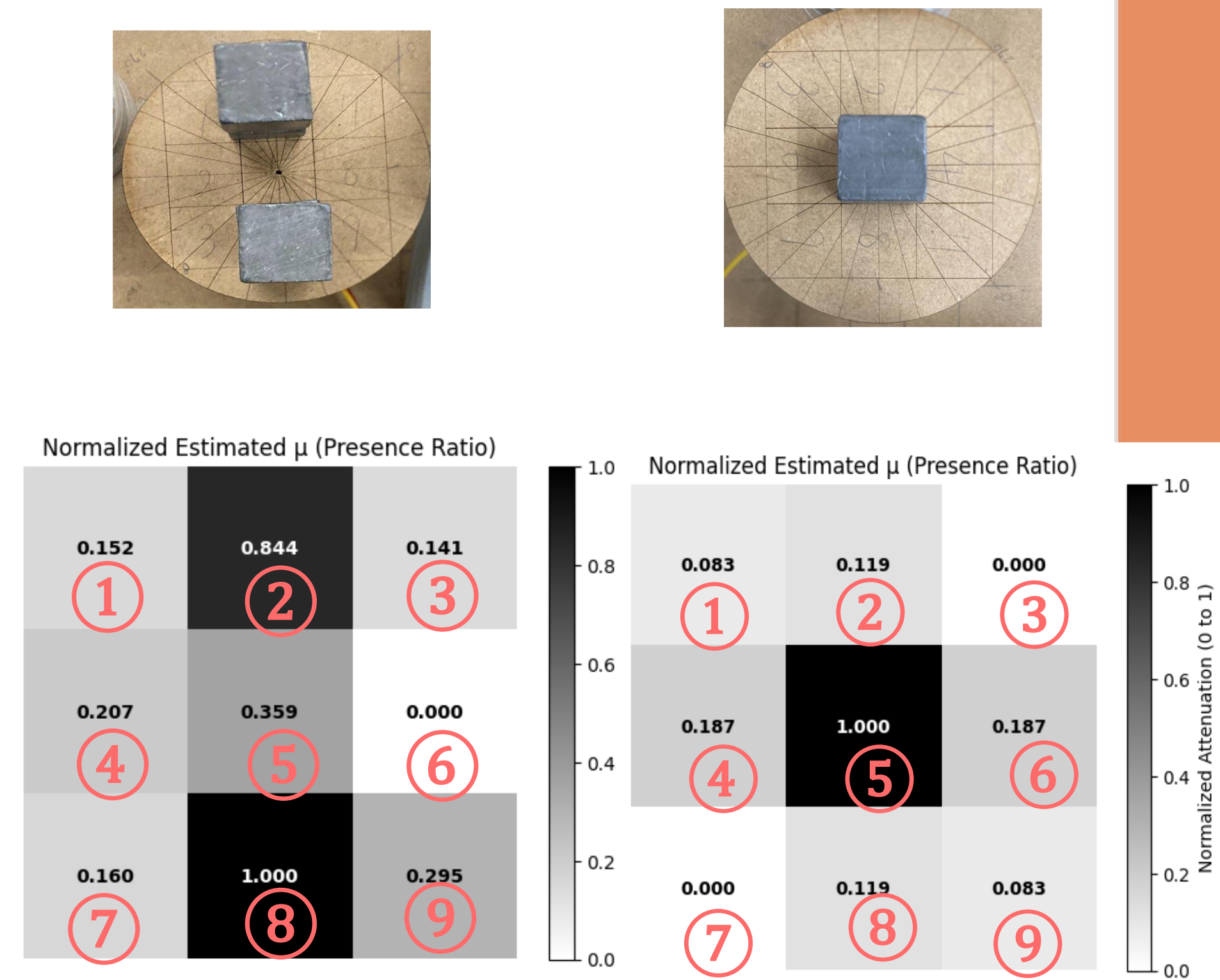


Results

Cells with lead showed clearly higher attenuation values.

Up to two lead blocks were correctly identified.

This method worked better than simple addition in the previous study.



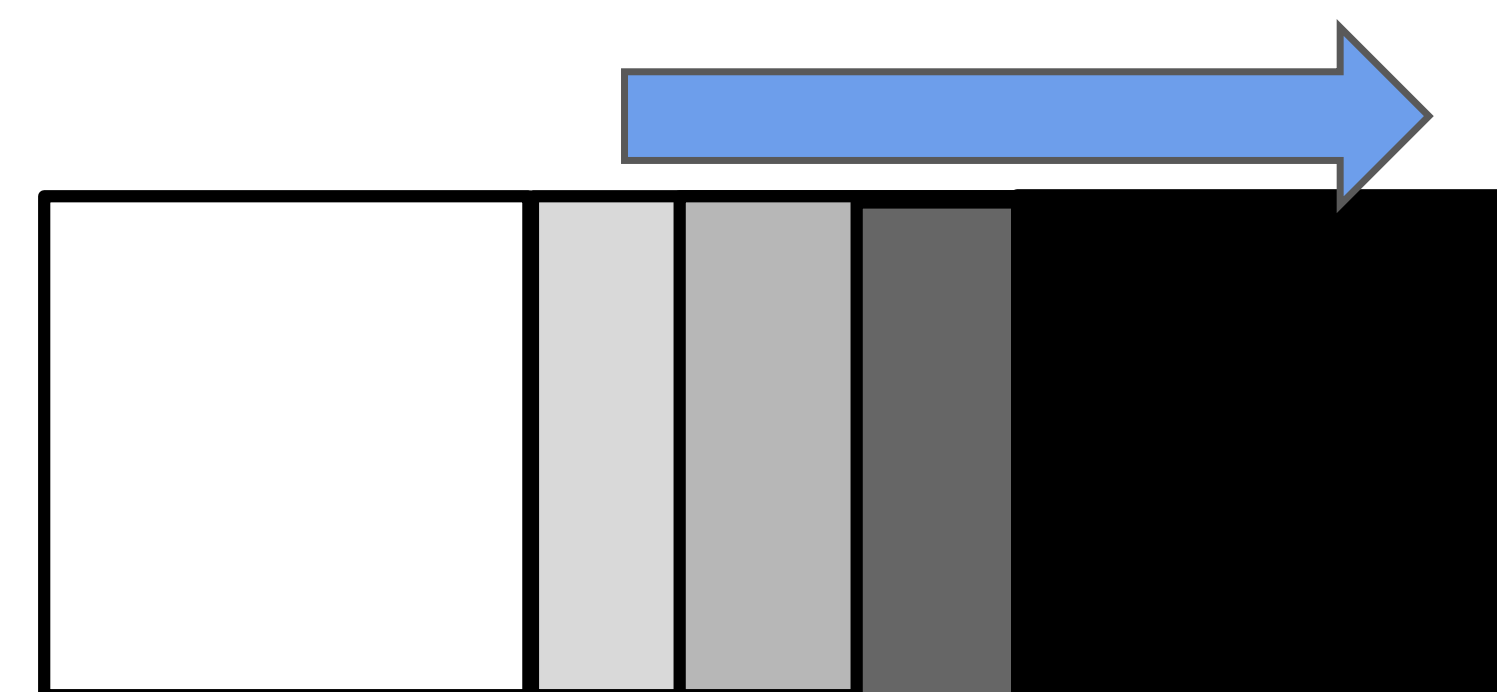
Analysis

More radiation reduced the effect of natural background noise.

Rotating the grid increased the number of measurement directions, which improved accuracy like CT imaging.

Future Work

- To create a quantitative threshold to judge "lead present."
- To test how small a movement of a block can be detected.
- To try blocks made of different materials such as copper.



Reference

[1] JST, "Seeing Inside Structures with Cosmic-Ray Muons," 2017.

URL: <https://www.jst.go.jp/pr/announce/20171106/> (Accessed: 2025-10-29)

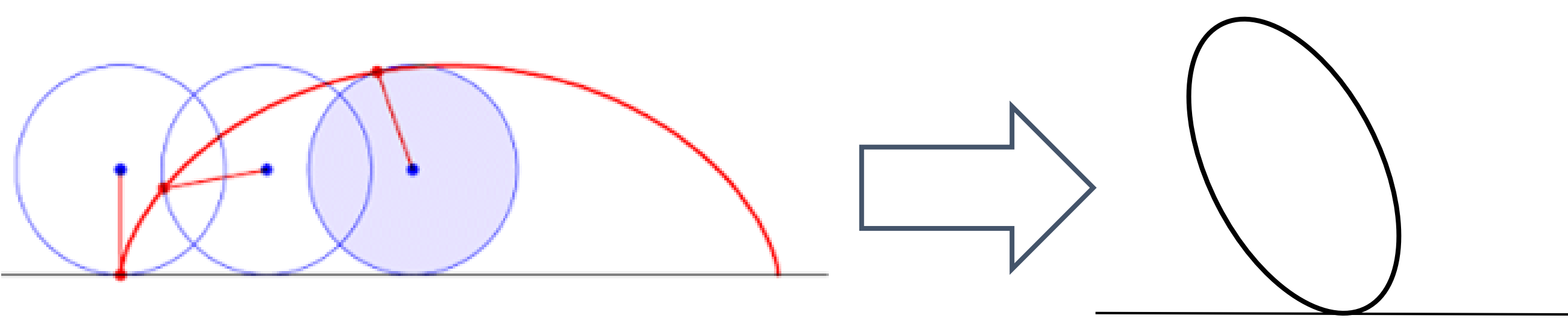
[2] K. Kanda et al., "Structural Analysis Using Cosmic Watch," *Tsukuba Science Edge* 2025, Poster, Tsukuba, 2025.



Behavior of a locus on an Ellipse rolling on a line

Introduction

When we researched the cycloid—the locus of a circle rolling on a straight line, we got interested in expanding this concept. Therefore we decided to investigate the locus traced by an ellipse rolling along a straight line.



Previous research

A previous study investigated the locus traced by a rolling ellipse. In this study, formulas describing the locus were derived; however, the properties of the locus have not yet been fully explored.

Purpose

The purpose of this study is to identify the properties of an ellipse by analyzing the locus generated by a rolling ellipse and by plotting this locus using a computer program.

Method

Initially, the center of the ellipse given by

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \quad (a > b > 0)$$

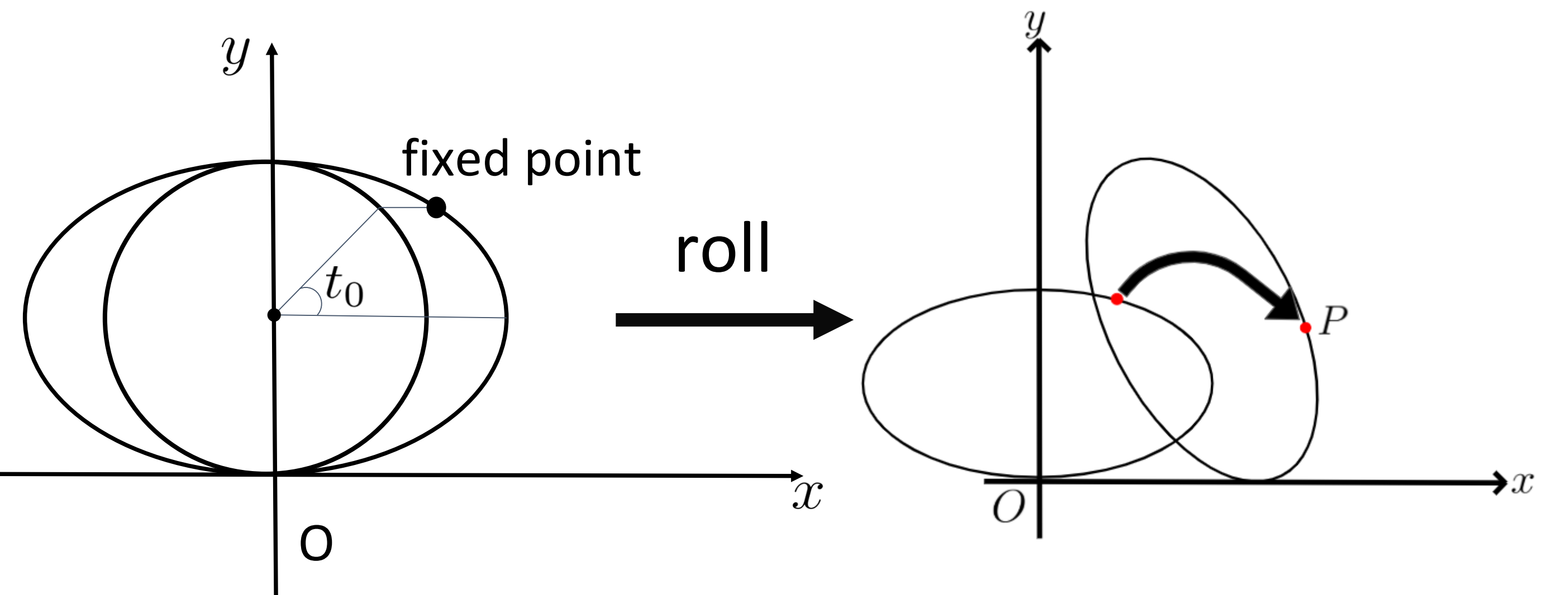
lies on the y-axis, and its major axis is parallel to the x-axis. Let the fixed point be $(a \cos t_0, b \sin t_0)$, and consider the locus traced by this point as the ellipse rolls along the x-axis without slipping. Using t as a parameter, the locus is given as follows.

$$x = \frac{b^2 \sin t_0}{r} \sin t + \frac{a^2 \cos t_0}{r} \cos t + \frac{\sin 2t}{r} \left(\frac{b^2}{2} - \frac{a^2}{2} \right) + L$$

$$y = \frac{ab}{r} (1 + \sin(t_0 - t))$$

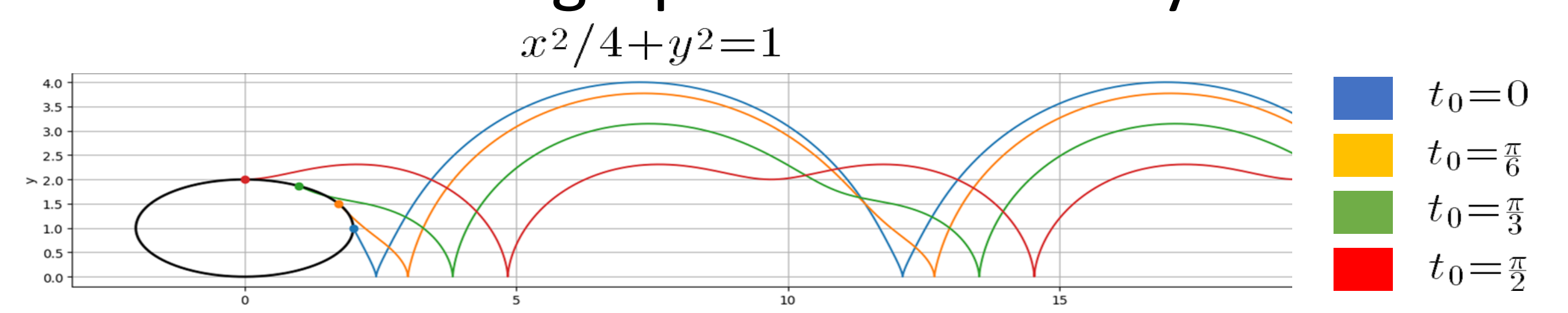
$$r = \sqrt{a^2 \cos^2 t + b^2 \sin^2 t}$$

$$L = \int_0^t \sqrt{a^2 \cos^2 x + b^2 \sin^2 x} dx$$



Results

We obtained the graph below with Python.



- the curve has continuity.
- the curve is smooth over a single period.
- There are some singular points.
- a local minimum was observed when $t_0 = \frac{\pi}{2}$.

Discussion

The value of t_0 , at which a local minimum first appears, is an important parameter. Since the singular points depend on t_0 , this parameter may reveal intrinsic properties of the locus.

Furthermore, investigating the length of the curve and the area between the curve and the x-axis may lead to the discovery of additional properties.

Conclusions

We derived the locus traced by an ellipse rolling along a straight line and plotted the corresponding graph using Python. Compared with the cycloid, the locus exhibits differences in both its shape and its properties. These differences suggest the possibility of discovering new properties through further investigation.

Reference

Mathematics C [数研出版]



Minimum Steiner Tree Problem for Five Distinct Points in the Plane

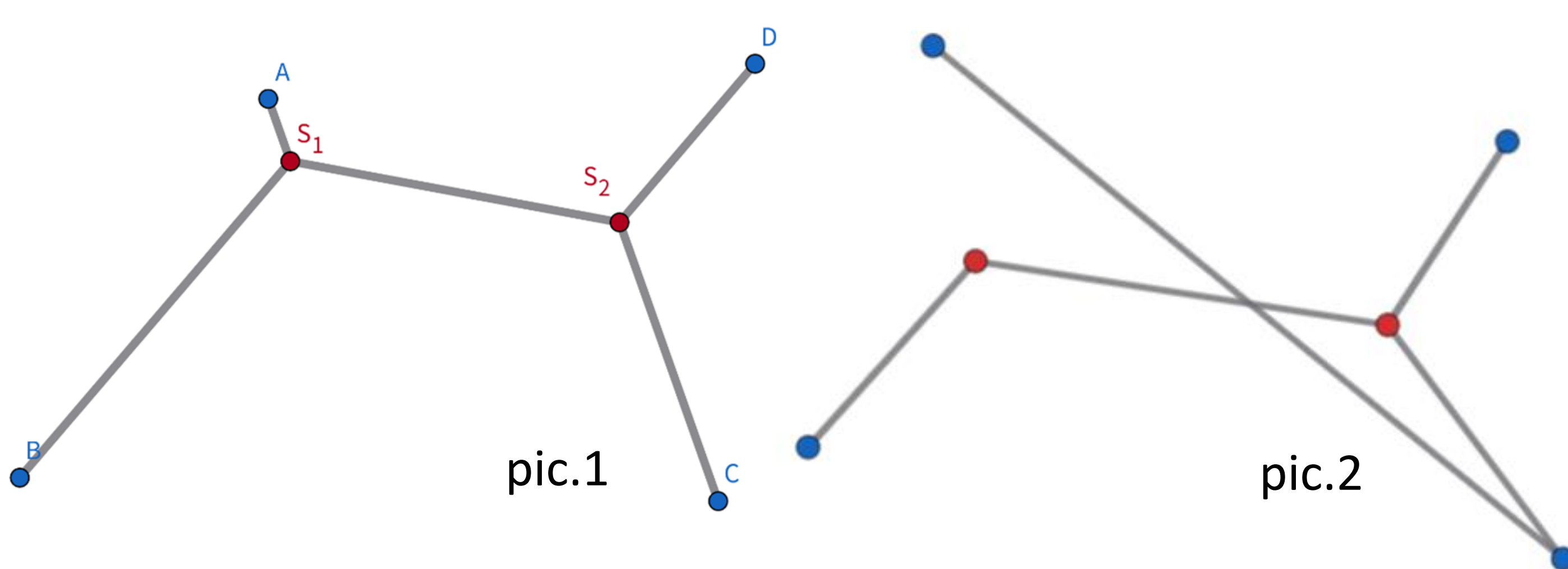
1. Introduction

“Steiner tree problem” is the problem of finding the minimum network which connects given points embedded in a plane(pic.1). In case three points are given(blue points), a junction point(red) is known as a Fermat point.

2.Previous Research

Properties satisfied by a Steiner tree T (like pic.1) with n elements in its minimal terminal set have been obtained as follows [1].

- The number k of Steiner points satisfies $0 \leq k \leq n-2$ (In pic.1, $k=n-2$).
- T is non-self intersecting. (cf. pic.2)
- The degree of every Steiner points is 3.
- a Steiner point is the Fermat point of the triangle formed by its connected points.
In pic.1, S_1 is connected to A,B, S_2 . $\triangle ABS_2$'s Fermat point is S_1 .
- The degree of any points belonging to the terminal set is at most 3.



3.Objective

Focusing on the number of points entered and the shape of the minimum Steiner tree, obtain the properties of the minimum Steiner tree and the solution to the Steiner tree problem.

4.Method

1. Derive properties concerning the minimum Steiner tree.

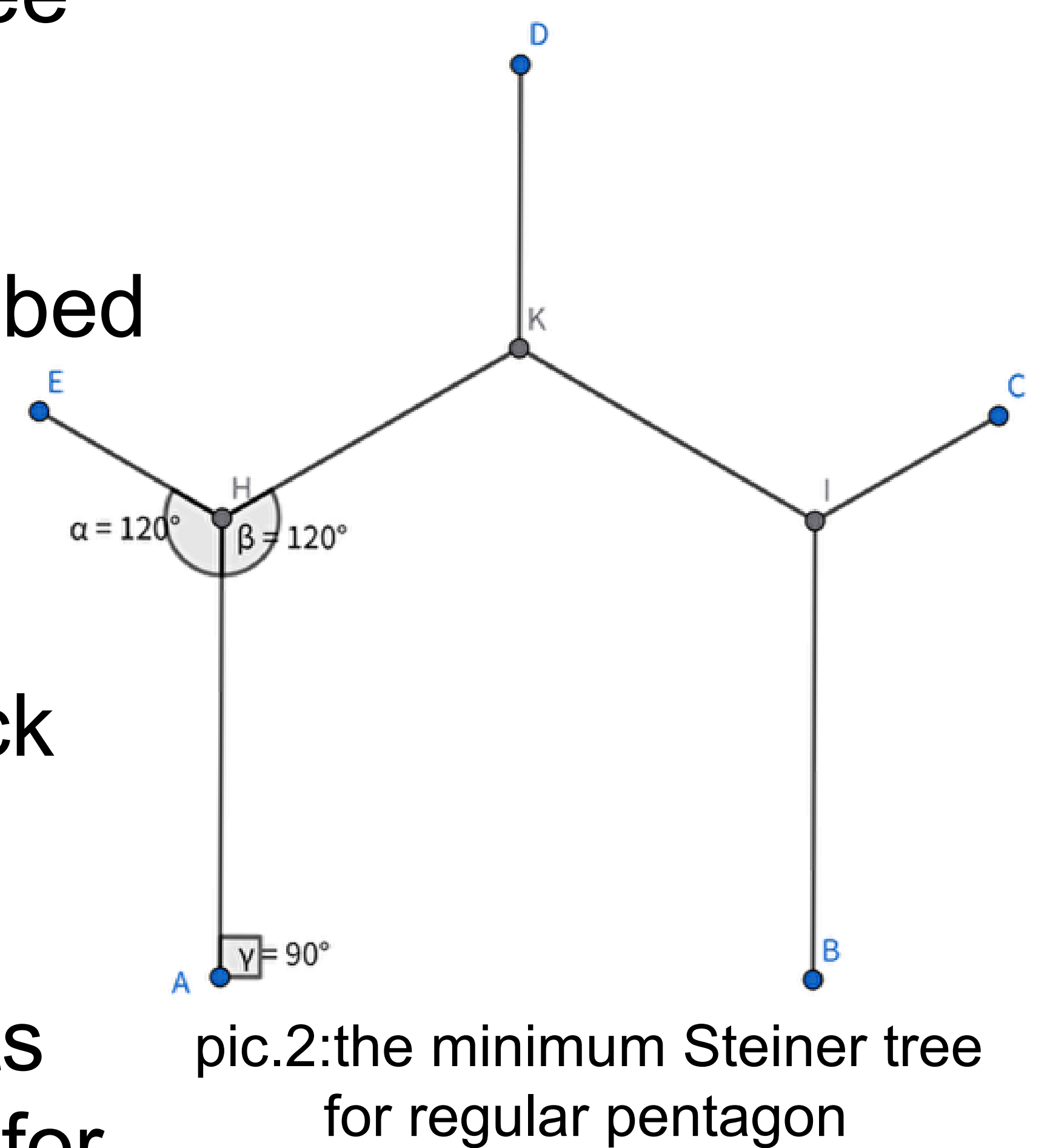
2. Construct a regular pentagon using the drawing software (GeoGebra).
3. Determine the Steiner point using the properties of the minimum Steiner tree.

5.Result

The following property was obtained for the minimum Steiner tree T:

- The angle formed by edges extending from any Steiner point is 120° .

Considering a tree that satisfies this property and the properties described in previous studies, only the graph formed by vertices and black edges as shown below and its rotational variants can be obtained for regular pentagons.(pic.2)



pic.2:the minimum Steiner tree for regular pentagon

6.Analysis and Conclusion

There exists only one tree satisfying the properties of the minimum Steiner tree for a regular pentagon, as shown in the figure above.This is the minimum Steiner tree with the set of vertices of the regular pentagon as its terminal set.

7.Future Prospects

This research has not yet yielded results for pentagons other than regular pentagons. Therefore, we aim to find the minimum Steiner tree for more general pentagons.

8.Reference

- [1] Z.A. Melzak, On the Problem of Steiner, Canadian Mathematical Bulletin, 2018



A study on factors affecting the duration of death feigning behavior in the red flour beetle

1,Background

The red flour beetle is a species of insect in the family Tenebrionidae of the order Coleoptera, that engages in a behavior where it retracts its legs and becomes immobile to avoid predation by natural enemies, which is called death feigning. Previous research has reported that the duration of this behavior increases with latitude.

2,Hypothese

Hypothesis 1: In environments with higher latitude and lower temperatures, the beetle prolongs death feigning to reduce energy consumption.

Hypothesis 2: Because the beetle is nocturnal, it becomes less active in environments with higher latitude and longer daylight hours

3,Procedure of experiment 1

① placed 20 adults in each of 3 petri dishes



② keeping them at 20°C, 25°C, 30°C for three weeks, we provoked death feigning and measured the duration of feigning

• we provoked death feigning by turning them over and stimulating their abdomen with tweezers

4,Result 1

temperature [°C]	number of surviving individuals	average[s]	variance
20°C	9	1.16	3.26
25°C	15	49.07	3034
30°C	19	7.16	1.46

Table 1 the relationship between temperature and death feigning

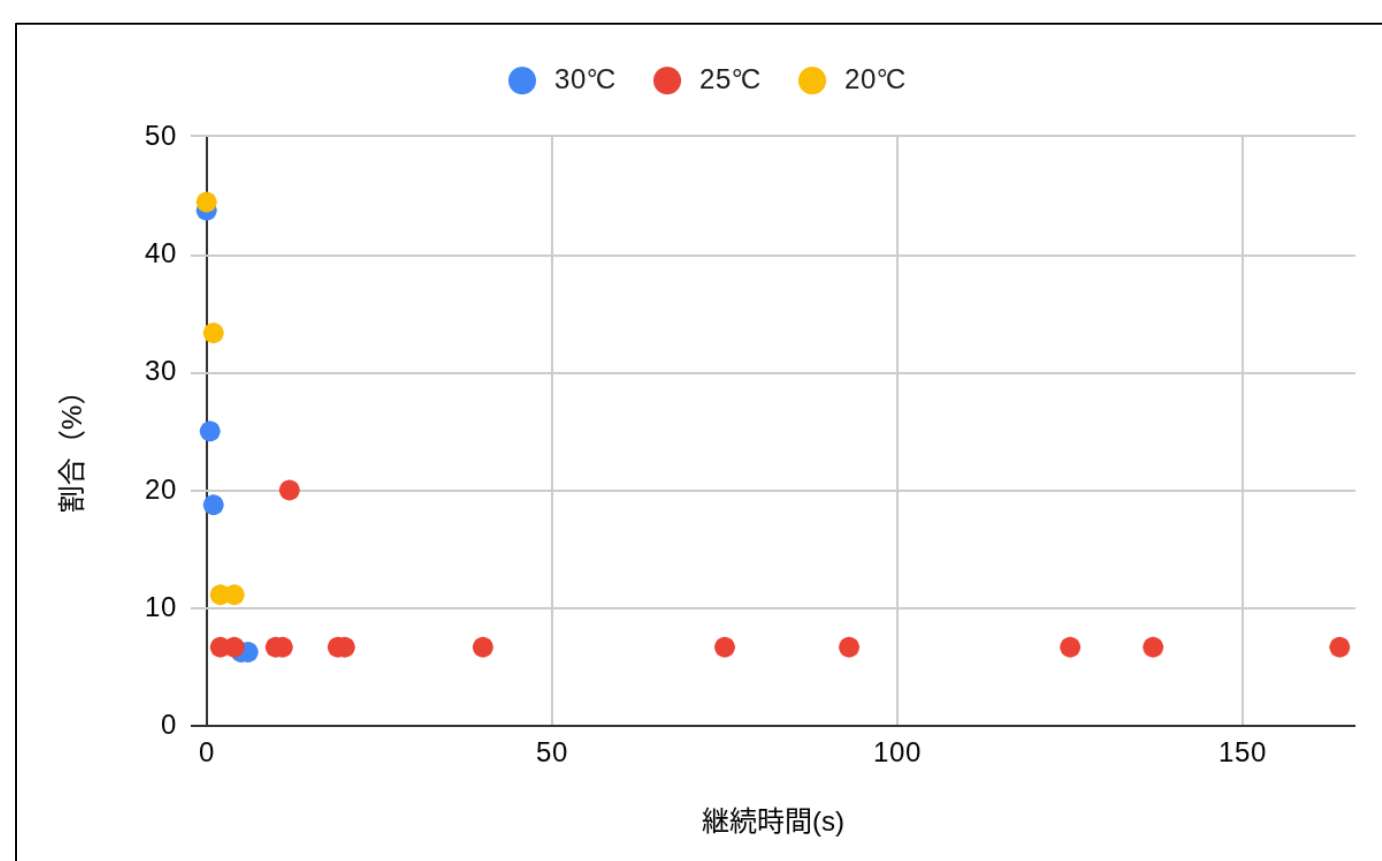


Figure 1 the between temperature and death feigning

5,Discussion 1

Since the number of surviving individuals at 20°C was extremely low, we concluded that 20°C is not a suitable temperature for growth. The results excluding 20°C suggest that at low temperatures, the animals prioritized death feigning over escape behavior in order to reduce energy consumption. The large variance in the 25°C was thought to be due to the fact that individual differences have a large effect on the duration of death feigning behavior in an environment where death feigning behavior is easily induced.

6,Procedure of experiment 2

① placed 20 adults in each of 3 petri dishes

② maintaining the light-dark cycle (24,0) (12,12)(0,24) for three weeks, provoked death feigning and measure the duration of feigning

• we provoked death feigning by turning them over and stimulating their abdomen with tweezers, like in experiment 1

7,Result 2

light-dark cycle	number of surviving individuals	Average value [s]	variance
0、24	18	1.17	3.67
12、12	16	3.94	2.40
24、0	19	6.39	51.3

Table2 the relationship between light-dark cycle and duration

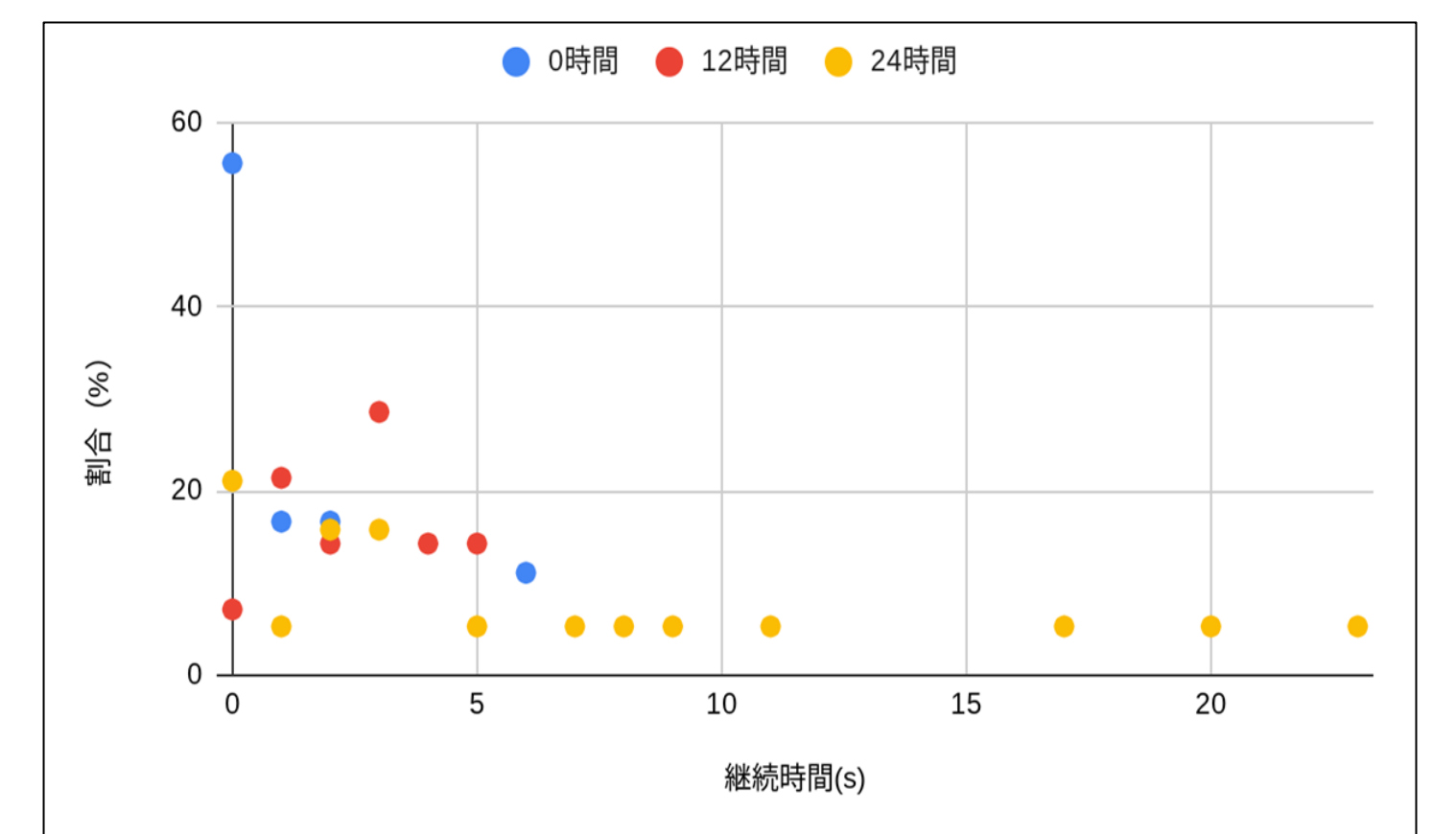


Figure2 the relationship between light-dark cycle and duration

8,Discussion 2

Since bright light slows down movement, it is thought that the animals prioritized death feigning behavior over escape behavior.

The large variance in the 24-hour light period was thought to be due to the fact that individual differences have a large effect on the duration of feigning.

9,Procedure of experiment 3

we focused on the growth stage among individuals differences.

① 24 pupae were placed in each of three petri dishes.

② After keeping the temperature at 25°C, 30°C, and 35°C for three weeks, death feigning behavior is induced and the duration is measured.

③ Each individual is tested multiple times

10,Conclusion

According to the result and discussion, it was concluded that the duration of death feigning behavior in the red flour beetle is affected by temperature and the hours of sunshine.

11,Prospect

In the future, we will investigate the amount of activity in specific environments and verify the insights gained from the results of this study. We will analyze the results of Experiment 3 and examine whether the growth stage affects the duration.

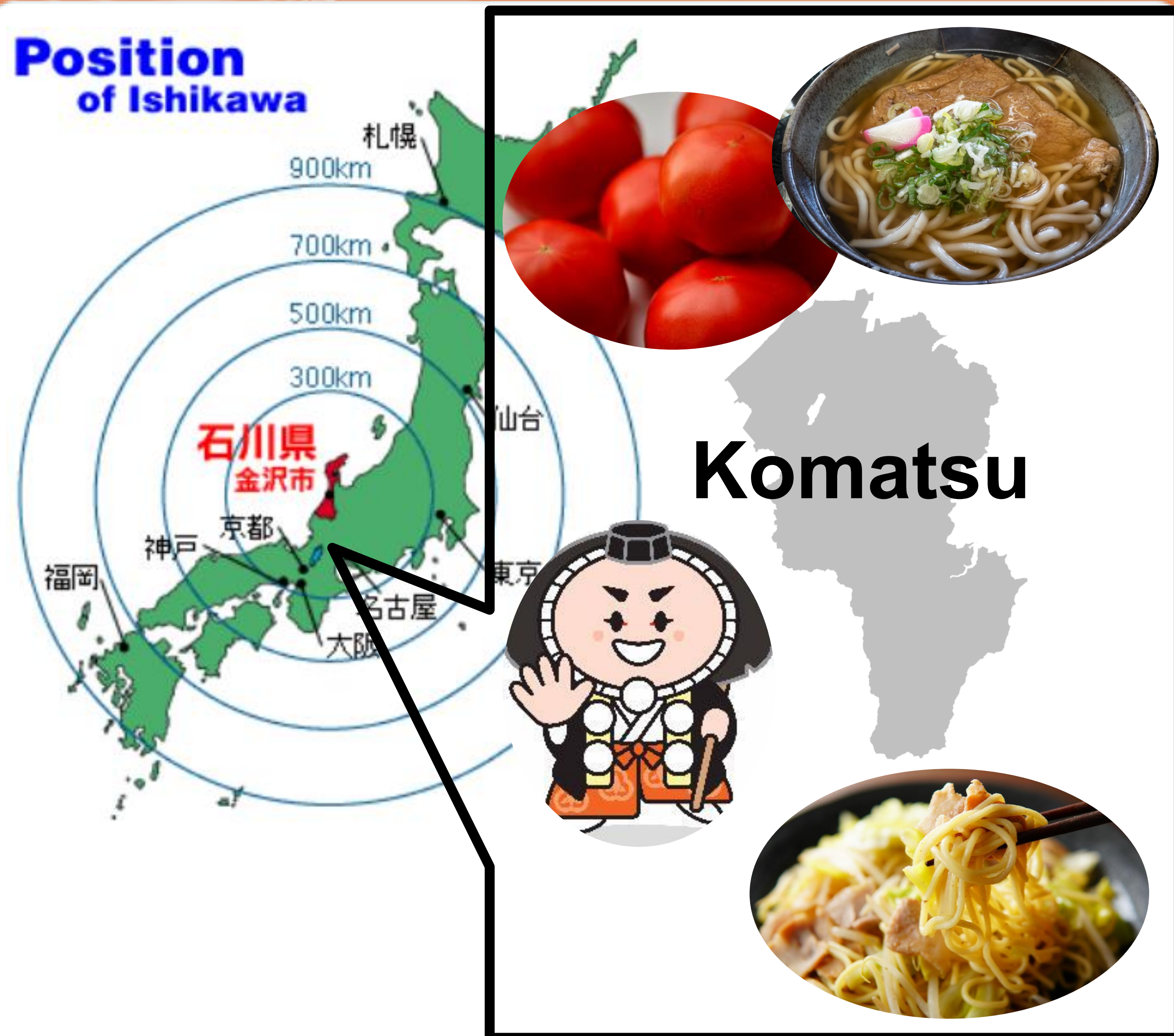
12,Reference

Kentarou Matsumura, Takahisa Miyatake. Latitudinal cline of death-feigning behaviour in a beetle (*Tribolium castaneum*). *Biology Letters*. 29 March 2023, volume 19, issue 3.

The strange strategy of creatures that "pretend to die and survive". Takehisa Miyatake. 2022, 9, 13. Iwanami Bookstore

Komatsu High School Days

Position of Ishikawa



School Trip in Hokkaido



School Festival



Sport Festival



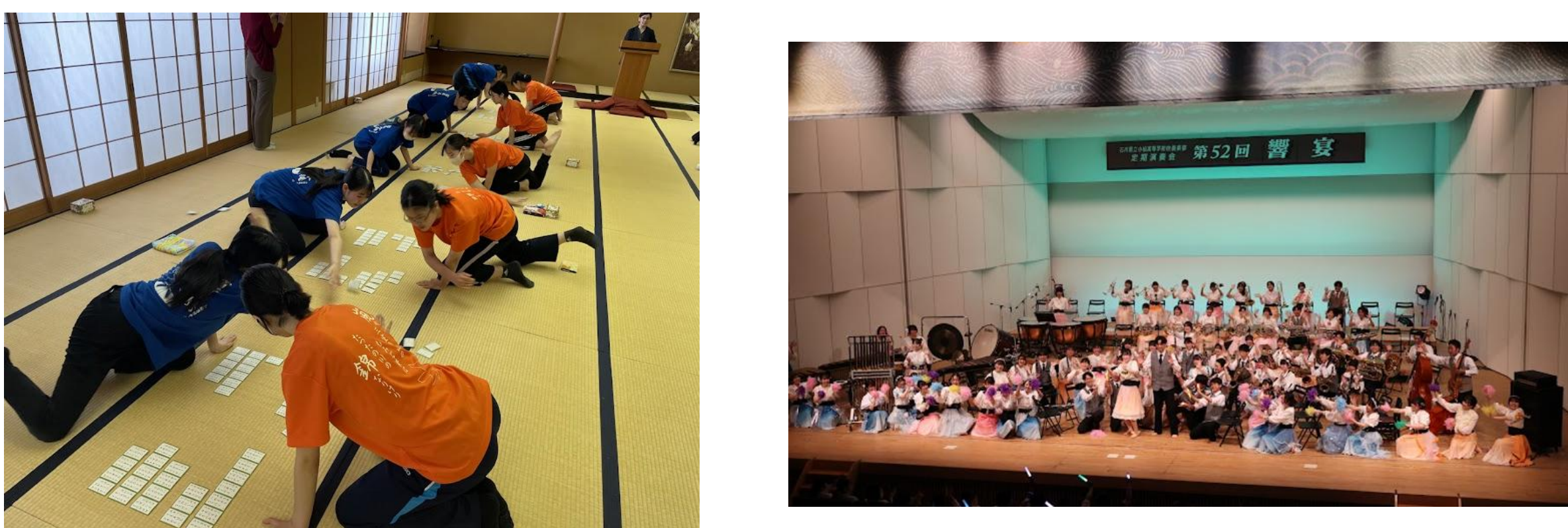
Our School



Class



Club Activity



Marathon Race



Research of sea urchin



Boat Race



Kanto Science Tour

