Device for experimental determination position of two magnetic balls

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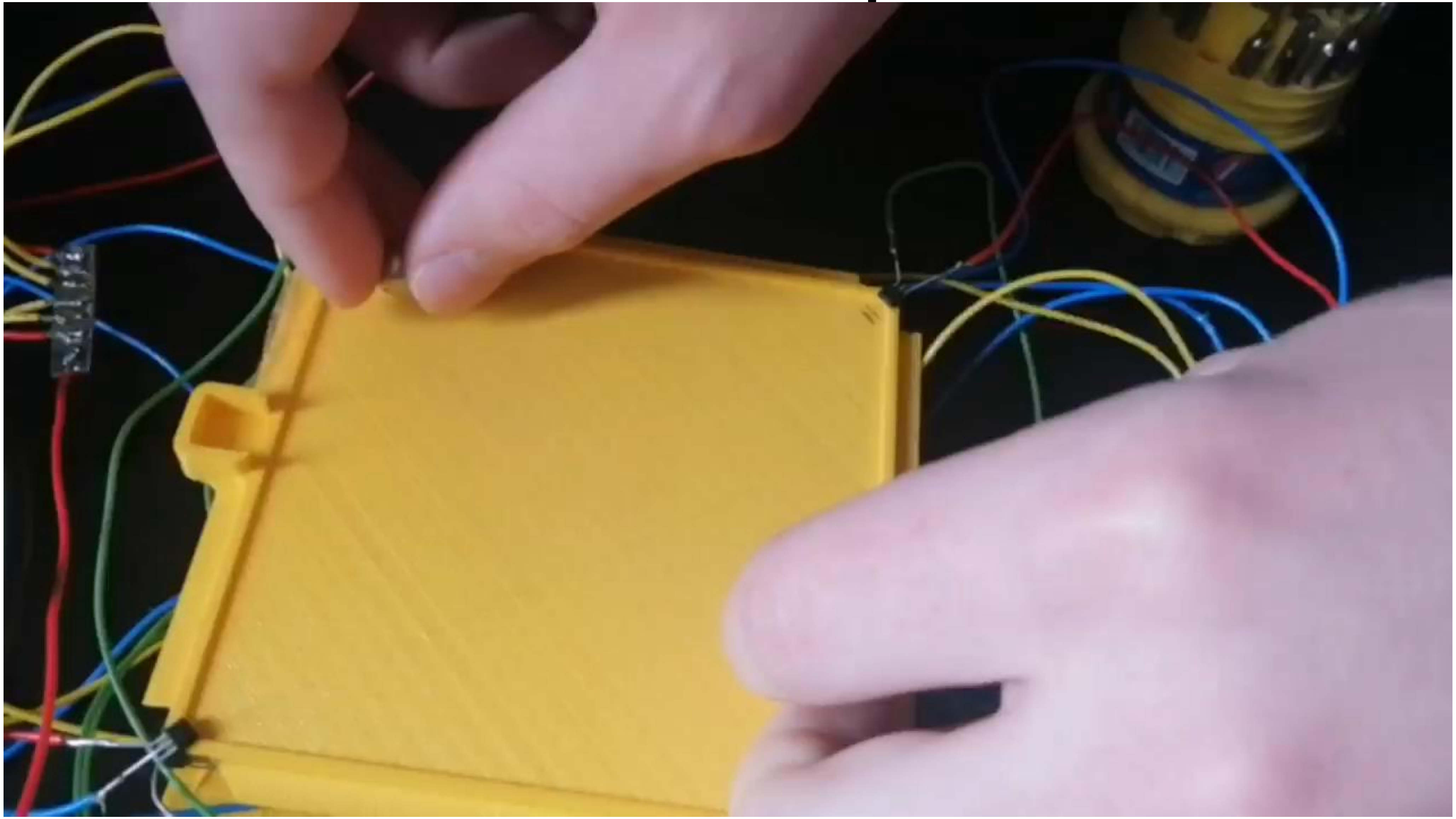
Topicality

In the research of the problem of N bodies that gravitationally interact, we encounter many interesting effects. However, gravitational interaction is only one of four fundamental interactions. That is why we consider the problem of two bodies interacting electromagnetically. In this case, we investigate the problem of two magnetic balls with different initial parameters. The study of such a problem can also be useful in astronomy. For example, many stars have a strong magnetic field, which may mean insufficient consideration of gravitational interactions in writing the laws of motion in this system. In contrast to the problem of N bodies in gravitational interaction, in this problem it is possible to obtain clear experimental results and compare with theoretical ones.

The video of experiment



Device for experimental determination position of two magnetic balls

The purpose of scientific research

Creating device which can determinate position of two magnetic balls

Tasks:

1. Develop the theoretical model for laws of moving magnetic balls.
2. Develop different PC simulations of moving magnetic balls using python.
3. Develop the method which can check the theory.
4. Create the device which can realize this method.
5. Test the device and find defects in working device.
6. Creating method which can give better preciseness of device.
7. Drawing conclusions for working device.

Originality of scientific research

For the first time war developed the method of researching the problem of two magnetic bodies with experimental checking

Device for experimental determination position of two magnetic balls

Theory

$$\overrightarrow{B_i} = \frac{\mu_0}{4\pi}\frac{3\overrightarrow{r_i}(\overrightarrow{r_i}\overrightarrow{m}) - \overrightarrow{m}r_i^2}{r_i^5}$$

$$\vec{B} = \sum_i \overrightarrow{B_i} = \frac{\mu_0}{4\pi}\sum_i \frac{3\overrightarrow{r_i}(\overrightarrow{r_i}\overrightarrow{m}) - \overrightarrow{m}r_i^2}{r_i^5} = \frac{\mu_0}{4\pi}\frac{M}{V}\oiiint \frac{3\overrightarrow{r_i}(\overrightarrow{r_i}\vec{p}) - \vec{p}r_i^2}{r_i^5}dV$$

Theory

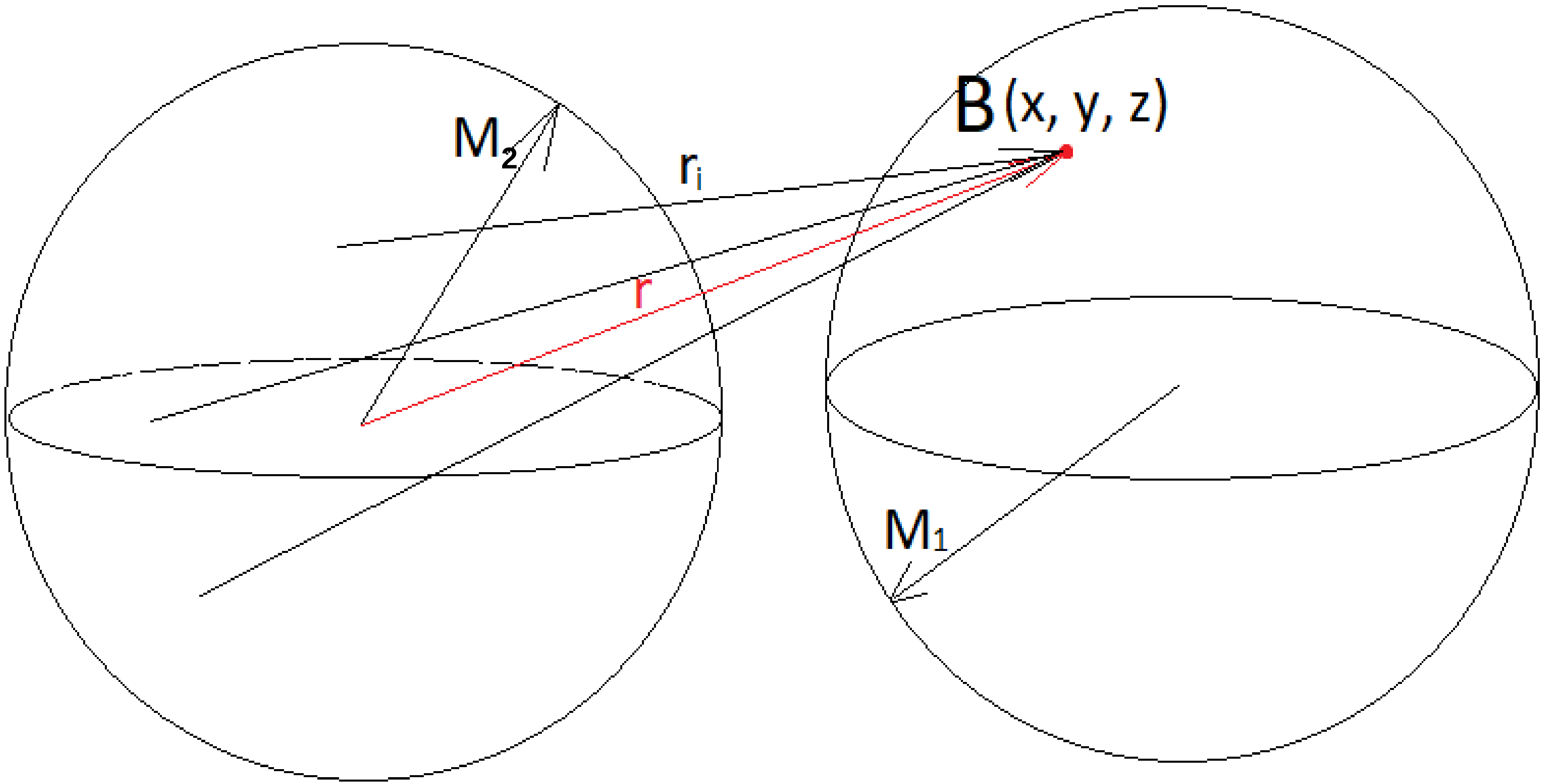


Fig. 1. Figure of two magnetic balls

Theory

$$\vec{F} = m\left(\frac{\partial B_x}{\partial x}\vec{i} + \frac{\partial B_y}{\partial y}\vec{j} + \frac{\partial B_k}{\partial z}\vec{k}\right)$$

$$\overrightarrow{M_f} = [\vec{m} \times \vec{B}]$$

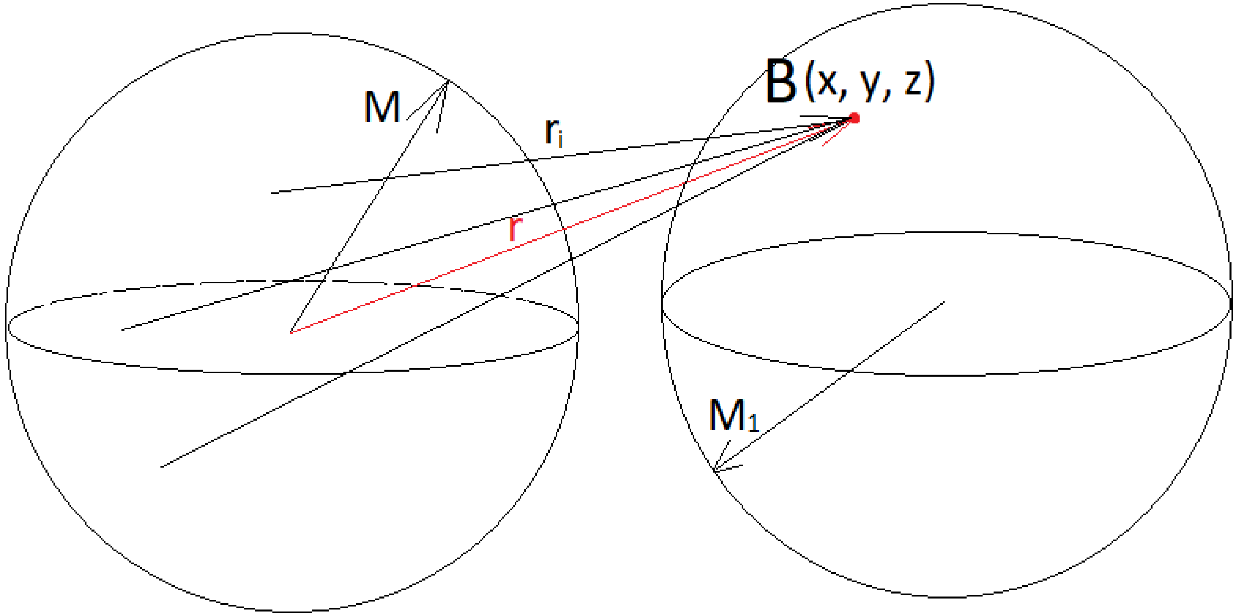
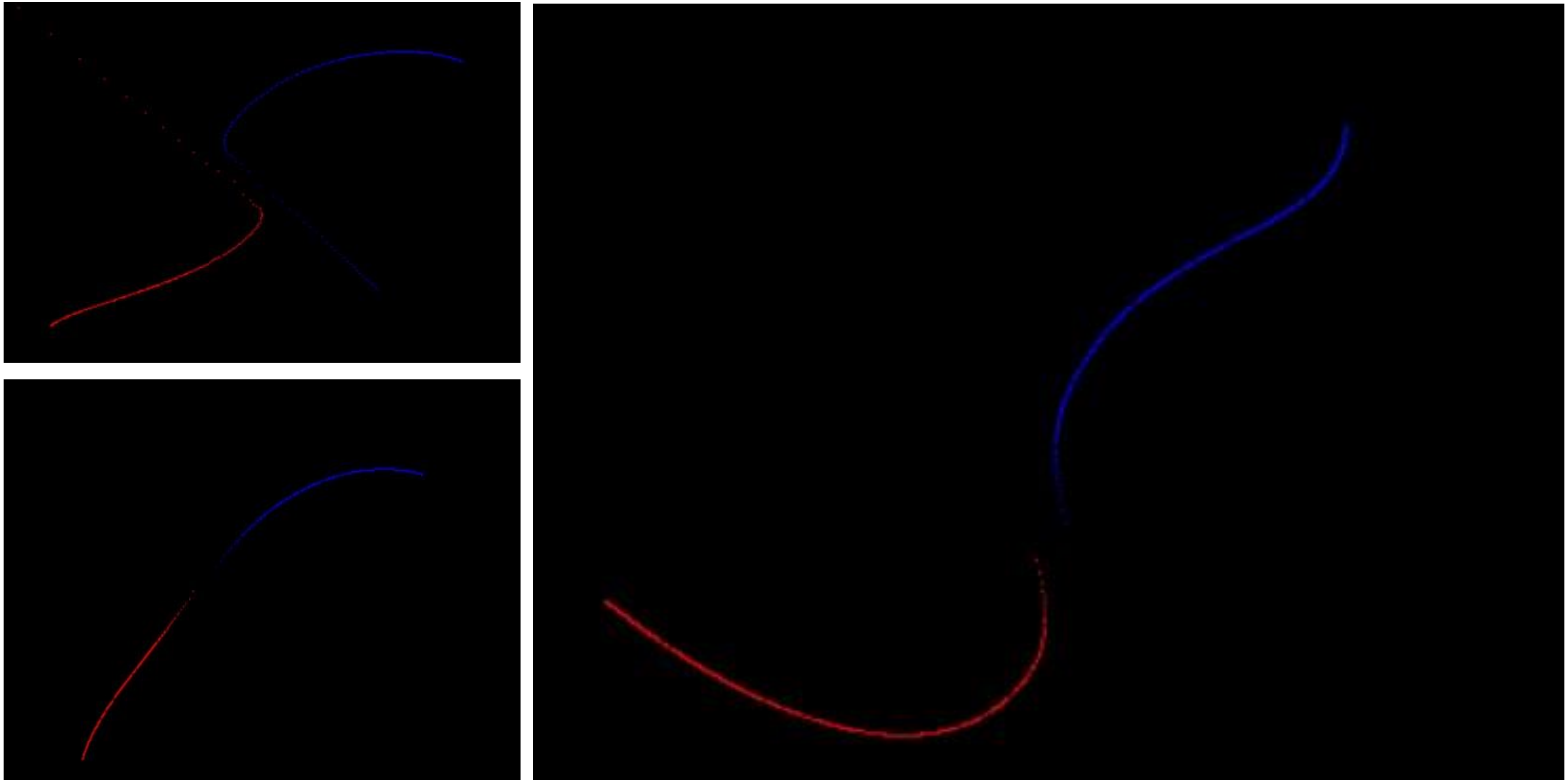


Fig. 1. Figure of two magnetic balls

$$m_* \overrightarrow{\ddot{q}_1} = \frac{M_1}{V_1} \oiiint \left(\frac{\partial B_q(M_2, V_2, \vec{r}_{2i})}{\partial q_1}\right) dV_1$$

$$I\ddot{\vec{\beta}}_1 = \frac{M_1}{V_1} \iiint \left(\left(\sum_q \frac{\partial B_q(M_2, V_2, \vec{r}_{2i})}{\partial q} \overrightarrow{e_q}\right) \times (\vec{L}_{2.1} - \vec{r}_{2i}) + [\overrightarrow{p_1} x B(M_2, V_2, \vec{r}_{2i})]\right) dV_1$$

Simulations



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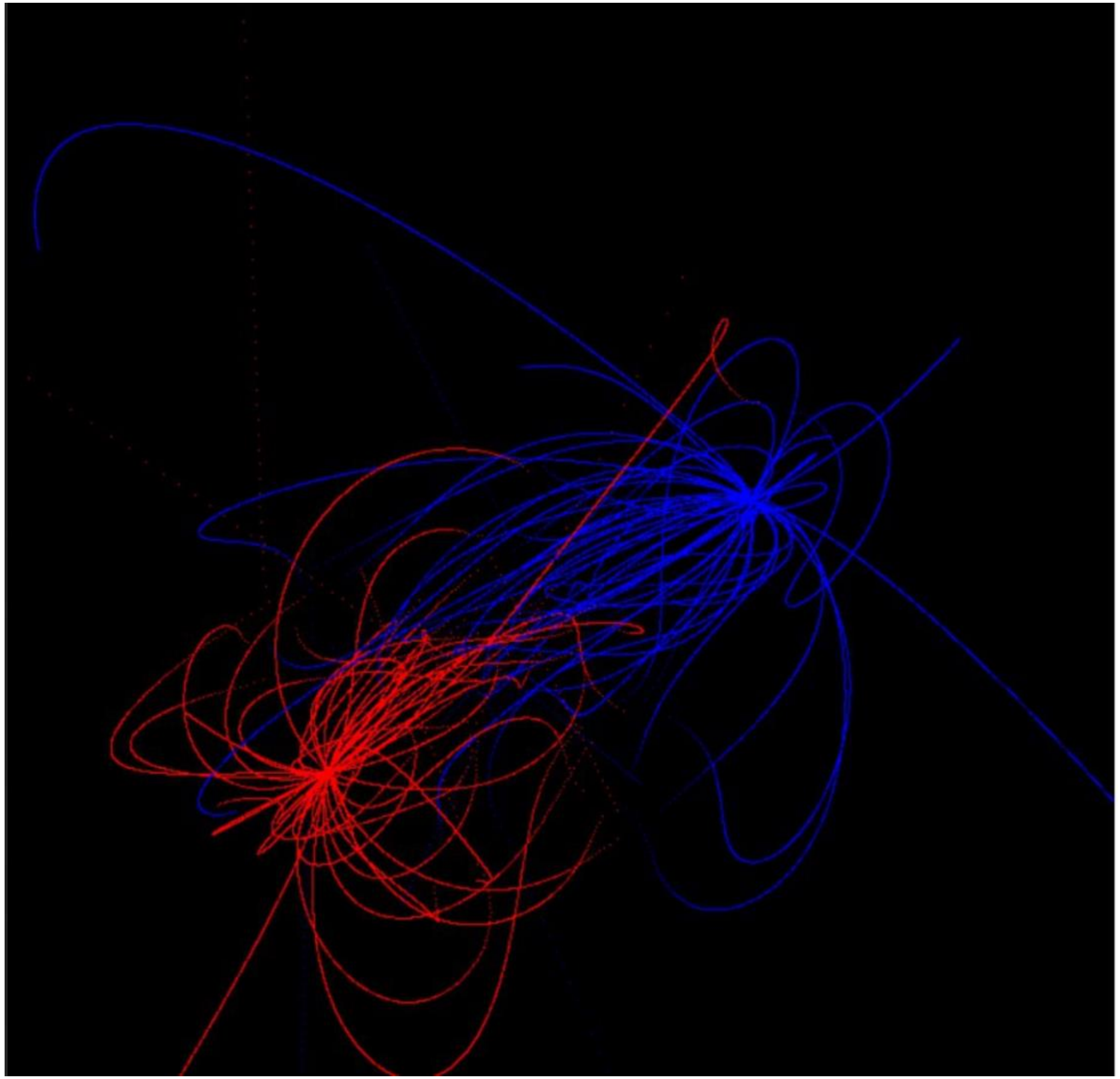
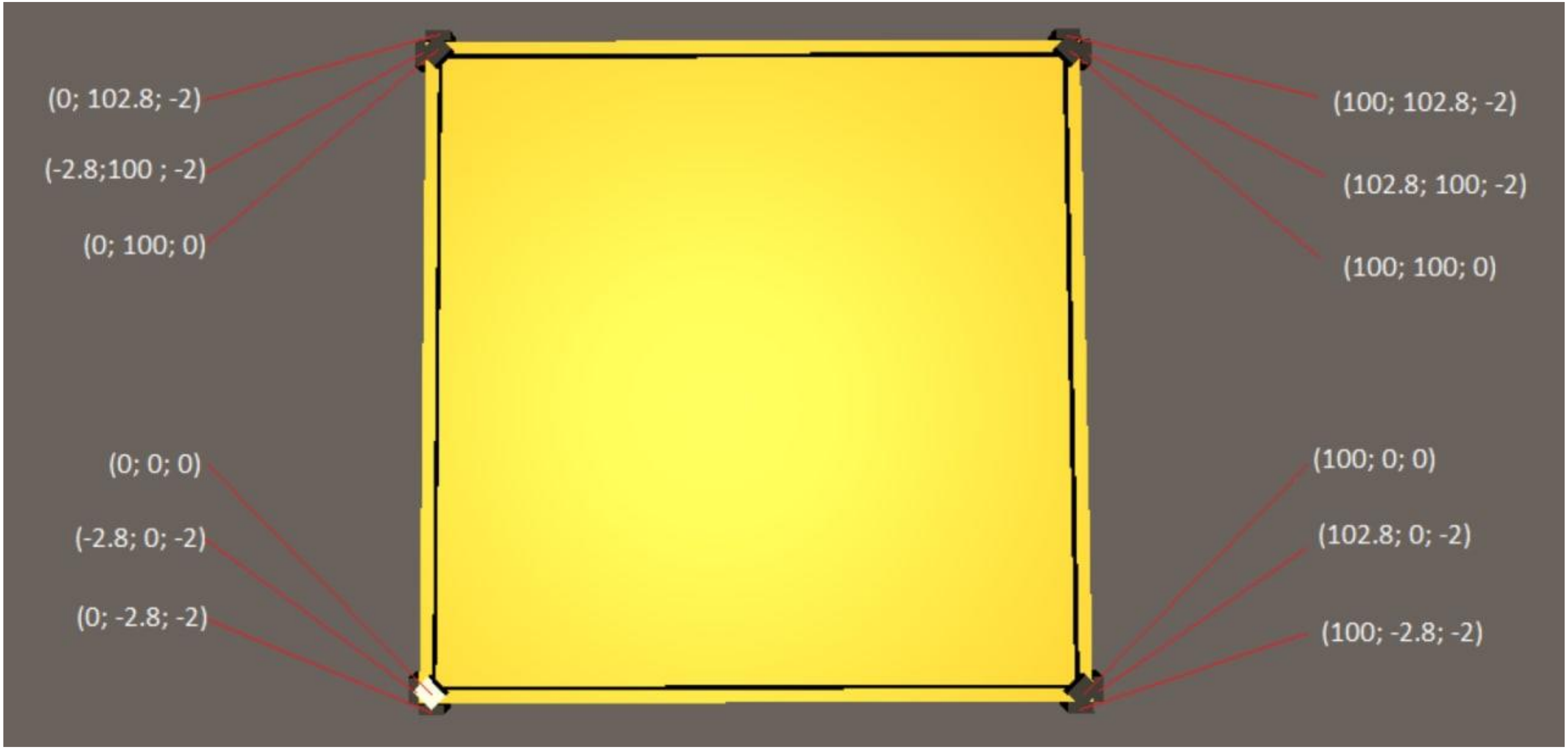
Simulations

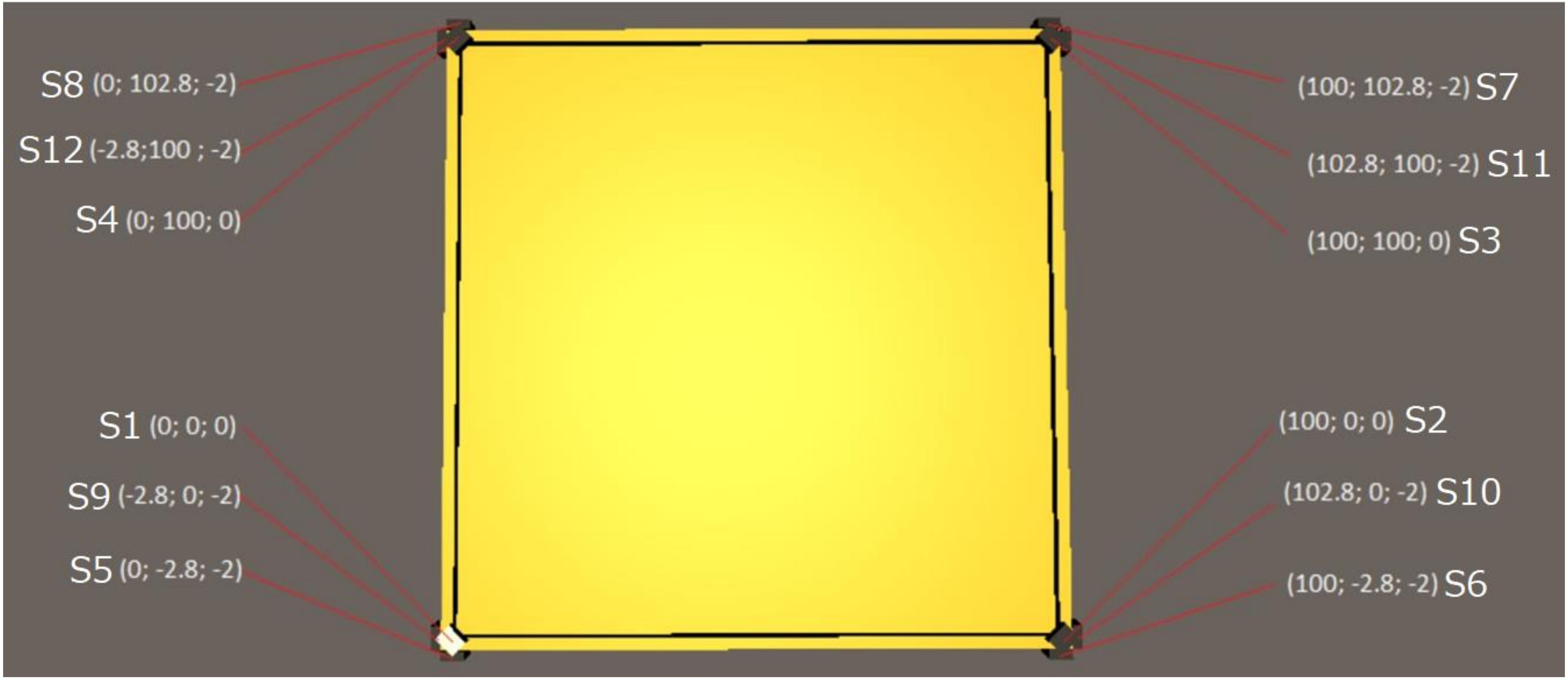


Device for experimental determination position of two magnetic balls

General idea of the device



General idea of the device



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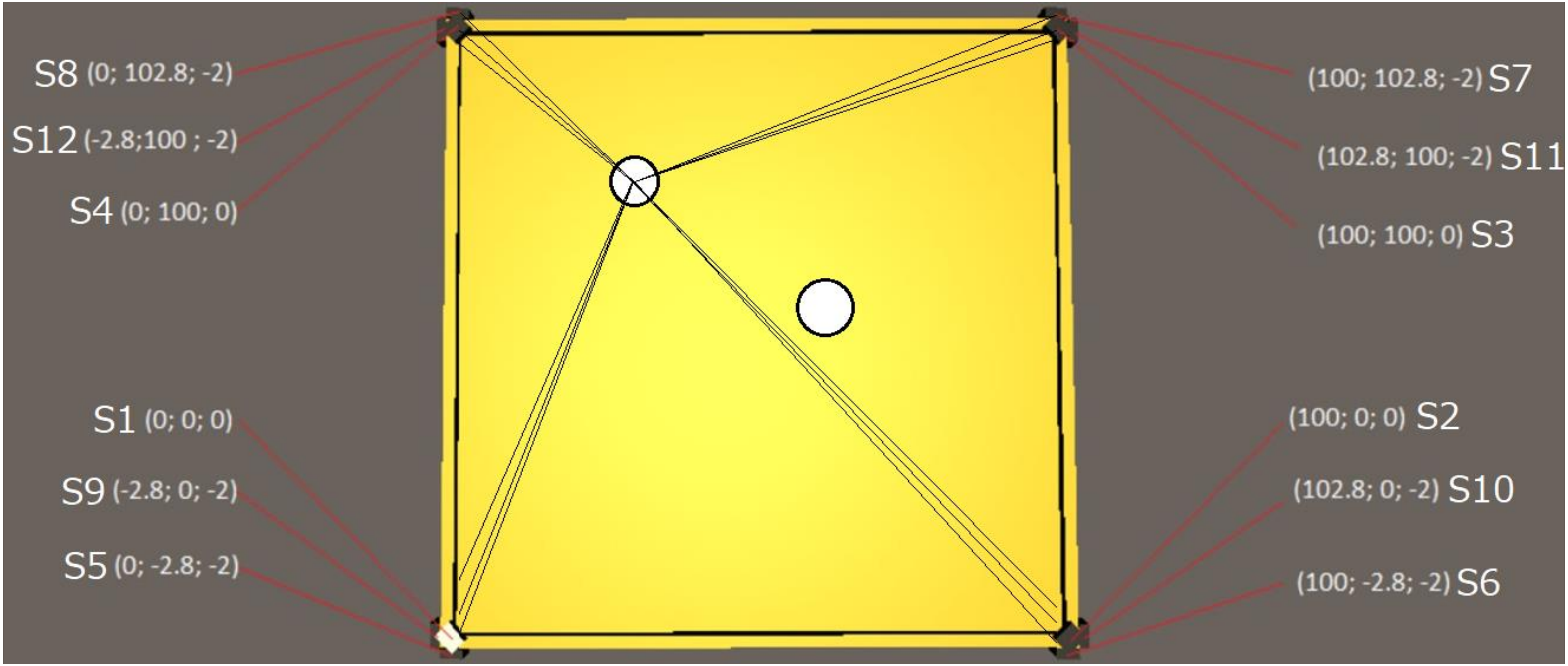
General idea of device the working



Device for experimental determination position of two magnetic balls

General idea of the device

$$\overrightarrow{B_i} = \frac{\mu_0}{4\pi}\frac{3\overrightarrow{r_{1i}}\left(\overrightarrow{r_{1i}}\overrightarrow{M_1}\right) - \overrightarrow{M_1}r_{2i}^2}{r_{1i}^5} + \frac{\mu_0}{4\pi}\frac{3\overrightarrow{r_{2i}}\left(\overrightarrow{r_{2i}}\overrightarrow{M_2}\right) - \overrightarrow{M_2}r_{2i}^2}{r_{2i}^5}$$

$$\overrightarrow{B_i} = \frac{\mu_0}{4\pi}\frac{1}{V_1}\oiiint \frac{3\overrightarrow{r_{1i}}\left(\overrightarrow{r_{1i}}\overrightarrow{M_1}\right) - \overrightarrow{M_1}r_{2i}^2}{r_{1i}^5}\,dV_1 + \frac{\mu_0}{4\pi}\frac{1}{V_2}\oiiint \frac{3\overrightarrow{r_{2i}}\left(\overrightarrow{r_{2i}}\overrightarrow{M_2}\right) - \overrightarrow{M_2}r_{2i}^2}{r_{2i}^5}\,dV_2$$

General idea of the device

$$\overrightarrow{B_1} = (B_{01}, -B_{05}, -B_{09})$$

$$\overrightarrow{B_2} = (B_{02}, -B_{06}, B_{10})$$

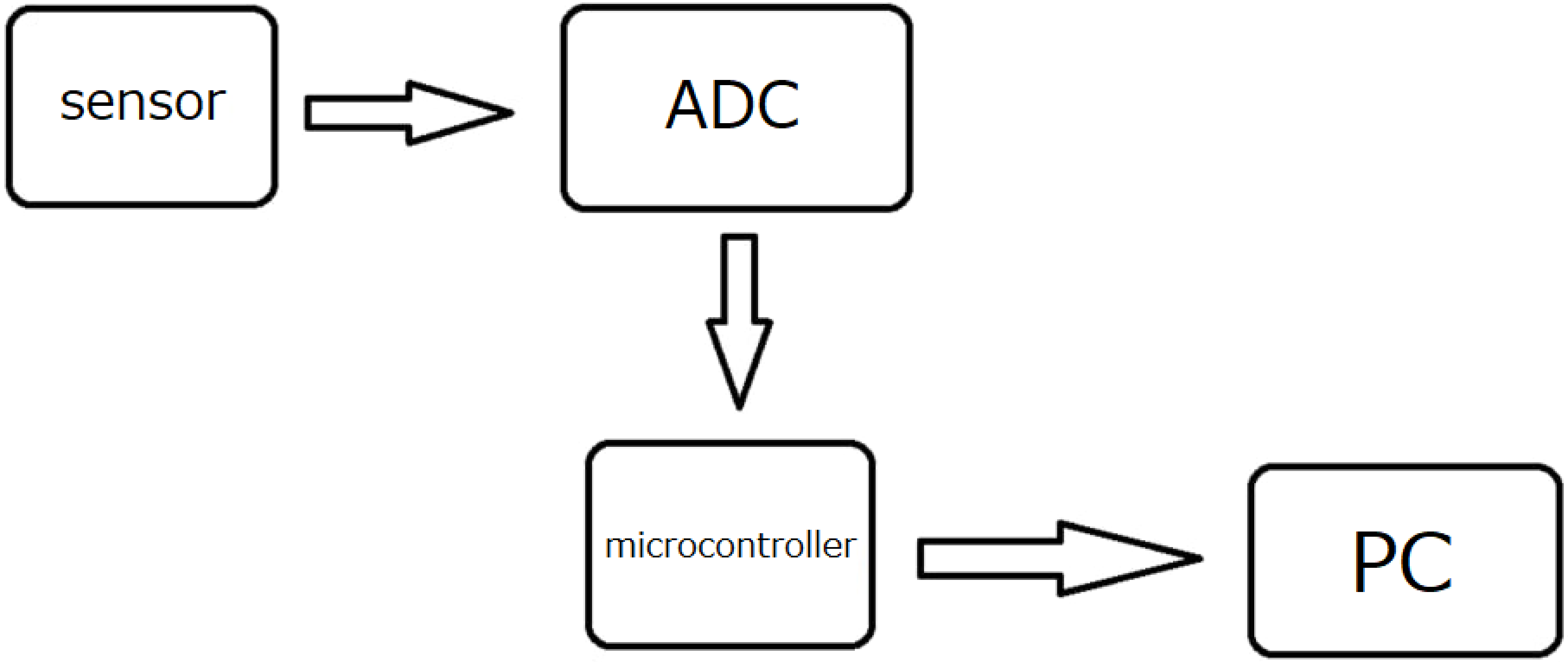
$$\overrightarrow{B_3} = (B_{03}, B_{07}, B_{11})$$

$$\overrightarrow{B_4} = (B_{04}, B_{08}, -B_{12})$$

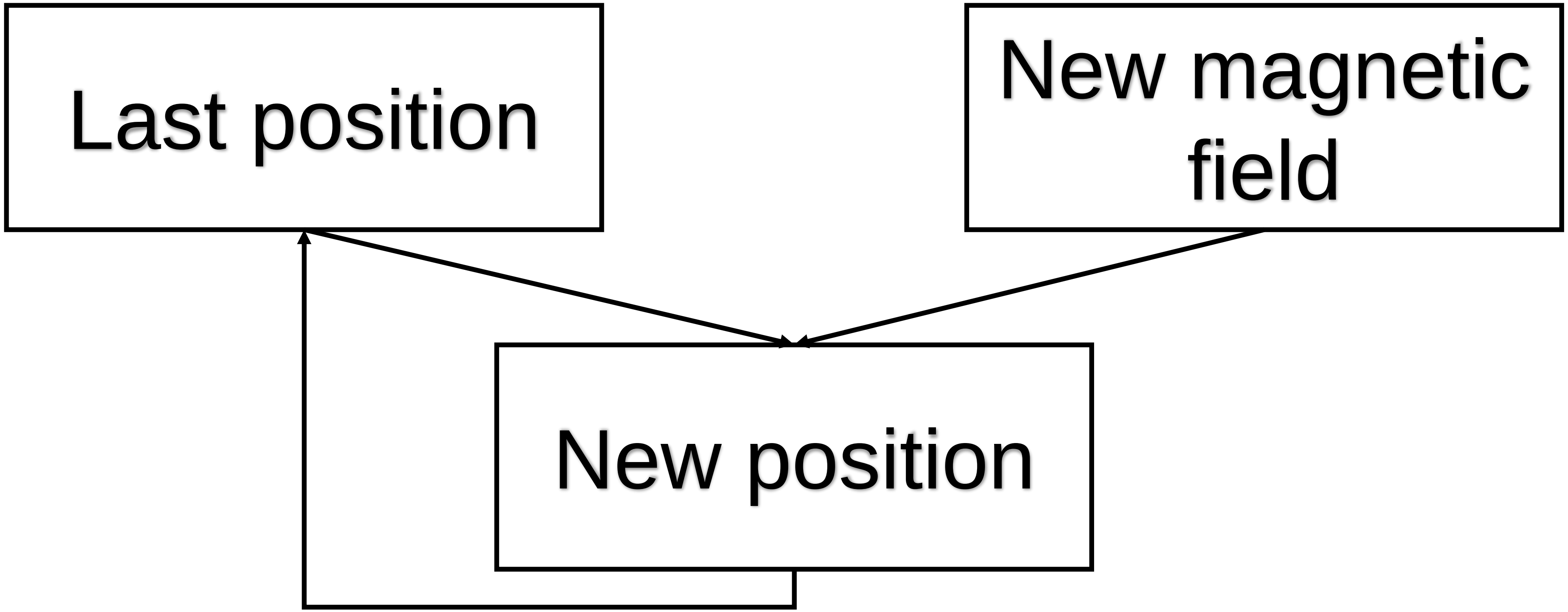
General idea of the device

$$\begin{cases}
\overrightarrow{B_1} = \frac{\mu_0}{4\pi}\frac{3\overrightarrow{r_{1.1}}\left(\overrightarrow{r_{1.1}}\overrightarrow{M_1}\right) - \overrightarrow{M_{1.1}}r_{2.1}^2}{r_{1.1}^5} + \frac{\mu_0}{4\pi}\frac{3\overrightarrow{r_{2.1}}\left(\overrightarrow{r_{2.1}}\overrightarrow{M_2}\right) - \overrightarrow{M_2}r_{2.1}^2}{r_{2.1}^5} \\
\overrightarrow{B_2} = \frac{\mu_0}{4\pi}\frac{3\overrightarrow{r_{1.2}}\left(\overrightarrow{r_{1.2}}\overrightarrow{M_1}\right) - \overrightarrow{M_{1.2}}r_{2.2}^2}{r_{1.2}^5} + \frac{\mu_0}{4\pi}\frac{3\overrightarrow{r_{2.2}}\left(\overrightarrow{r_{2.2}}\overrightarrow{M_2}\right) - \overrightarrow{M_2}r_{2.2}^2}{r_{2.2}^5} \\
\overrightarrow{B_3} = \frac{\mu_0}{4\pi}\frac{3\overrightarrow{r_{1.3}}\left(\overrightarrow{r_{1.3}}\overrightarrow{M_1}\right) - \overrightarrow{M_{1.3}}r_{2.3}^2}{r_{1.3}^5} + \frac{\mu_0}{4\pi}\frac{3\overrightarrow{r_{2.3}}\left(\overrightarrow{r_{2.3}}\overrightarrow{M_2}\right) - \overrightarrow{M_2}r_{2.3}^2}{r_{2.3}^5} \\
\overrightarrow{B_4} = \frac{\mu_0}{4\pi}\frac{3\overrightarrow{r_{1.4}}\left(\overrightarrow{r_{1.4}}\overrightarrow{M_1}\right) - \overrightarrow{M_{1.1}}r_{2.4}^2}{r_{1.4}^5} + \frac{\mu_0}{4\pi}\frac{3\overrightarrow{r_{2.1}}\left(\overrightarrow{r_{2.4}}\overrightarrow{M_2}\right) - \overrightarrow{M_2}r_{2.4}^2}{r_{2.4}^5}
\end{cases}$$

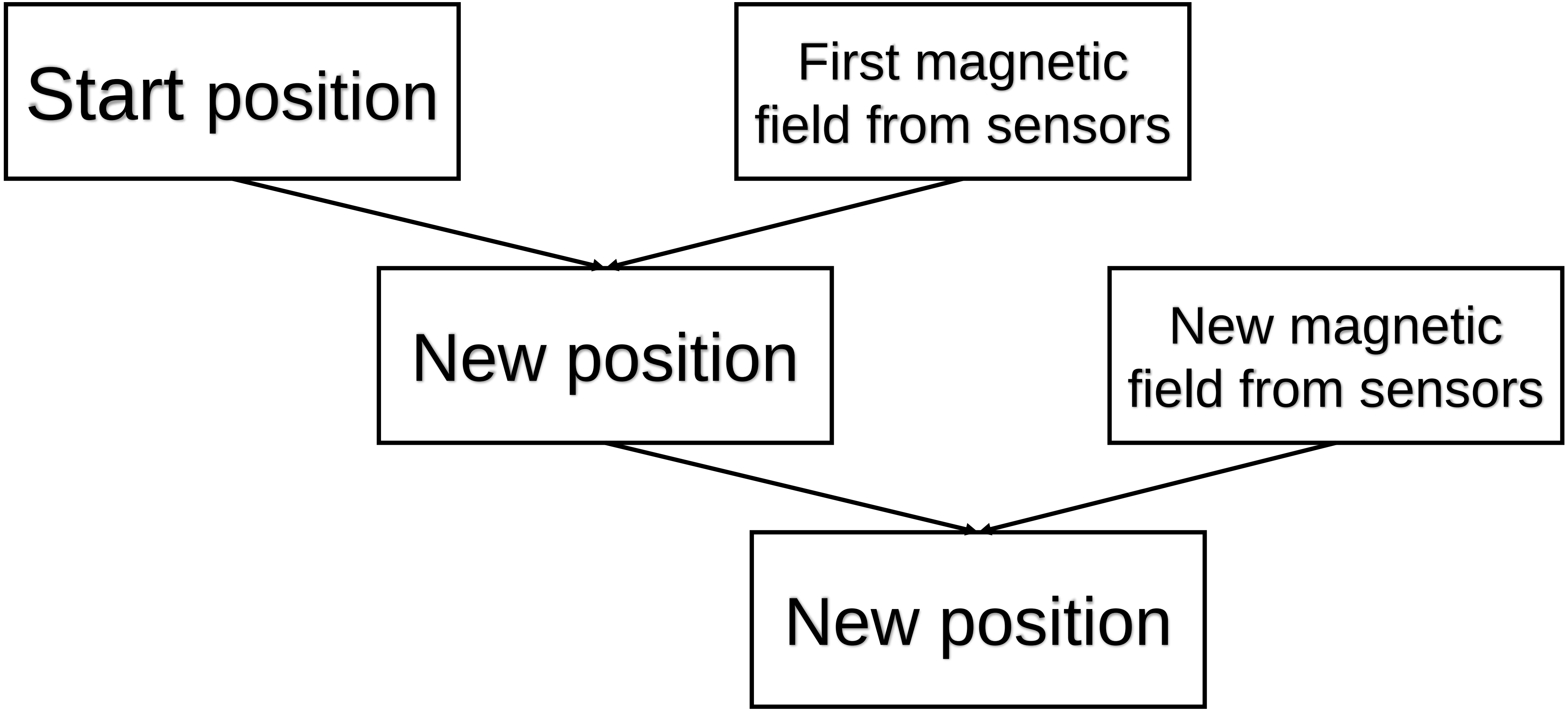
General idea of the device



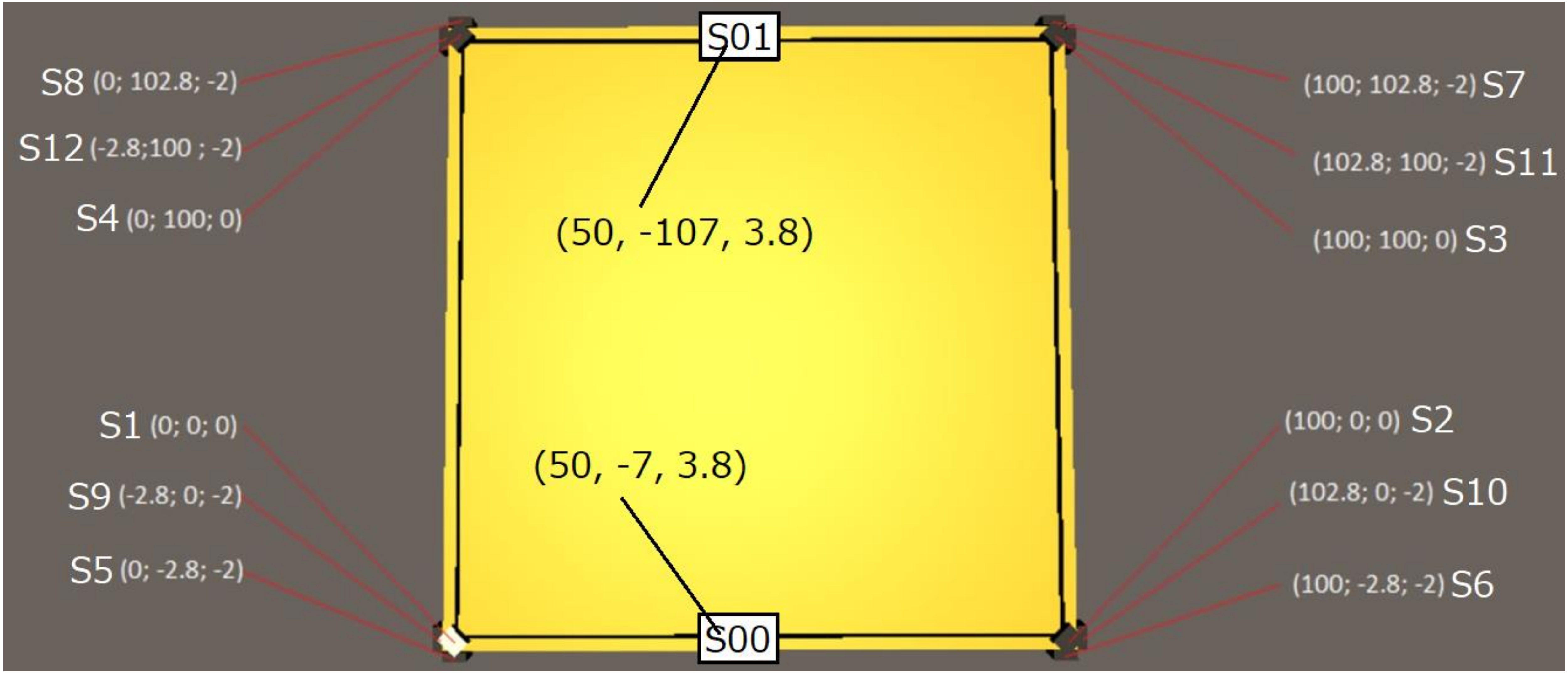
General idea of the device



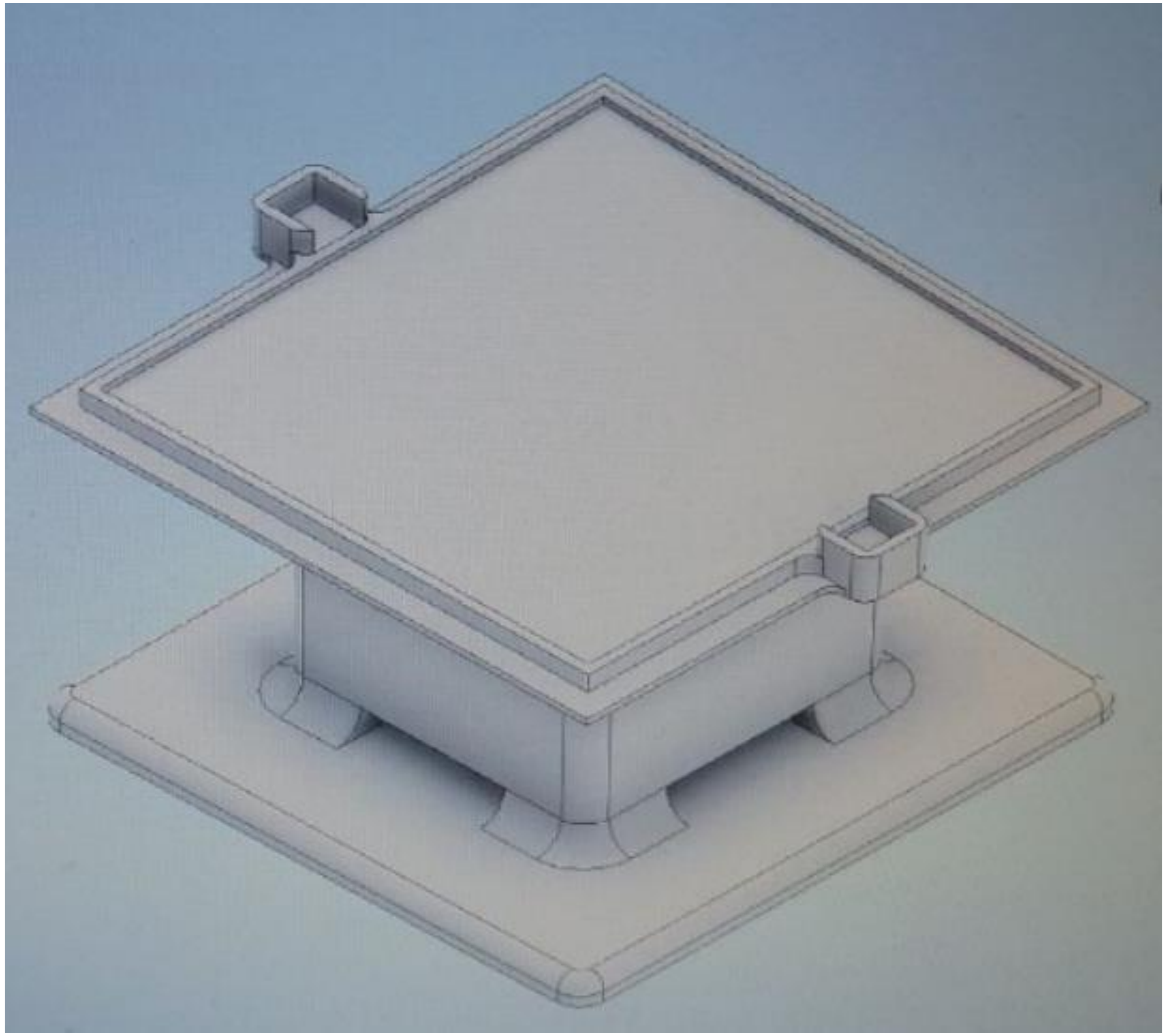
General idea of the device



Calibration sectors



Calibration sectors



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Calibration sectors

$$
\begin{cases}
\left(\frac{x_i^2}{r_i^5}-\frac{1}{r_i^3}\right)M_x+\left(\frac{x_i y}{r_i^5}\right)M_y+\left(\frac{x_i z_i}{r_i^5}\right)M_z=(\overrightarrow{B_i})_x \\
\left(\frac{y_i x_i}{r_i^5}\right)M_x+\left(\frac{y_i^2}{r_i^5}-\frac{1}{r_i^3}\right)M_y+\left(\frac{y_i z_i}{r_i^5}\right)M_z=(\overrightarrow{B_i})_y \\
\left(\frac{z_i x_i}{r_i^5}\right)M_x+\left(\frac{z_i y_i}{r_i^5}\right)M_y+\left(\frac{z_i^2}{r_i^5}-\frac{1}{r_i^3}\right)M_z=(\overrightarrow{B_i})_z
\end{cases}
$$

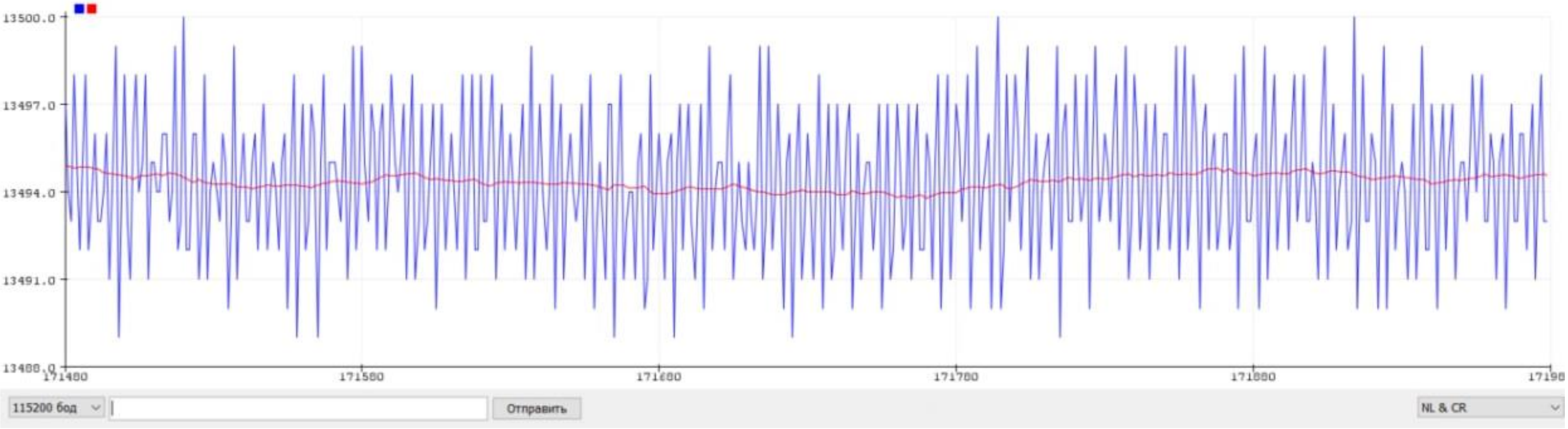
Calibration sectors

$$\vec{M} = \begin{pmatrix} \left(\frac{x_i^2}{r_i^5} - \frac{1}{r_i^3}\right) & \left(\frac{x_i y}{r_i^5}\right) & \left(\frac{x_i z_i}{r_i^5}\right) \\ \left(\frac{y_i x_i}{r_i^5}\right) & \left(\frac{y_i^2}{r_i^5} - \frac{1}{r_i^3}\right) & \left(\frac{y_i z_i}{r_i^5}\right) \\ \left(\frac{z_i x_i}{r_i^5}\right) & \left(\frac{z_i y_i}{r_i^5}\right) & \left(\frac{z_i^2}{r_i^5} - \frac{1}{r_i^3}\right) \end{pmatrix}^{-1} \vec{B_i}$$

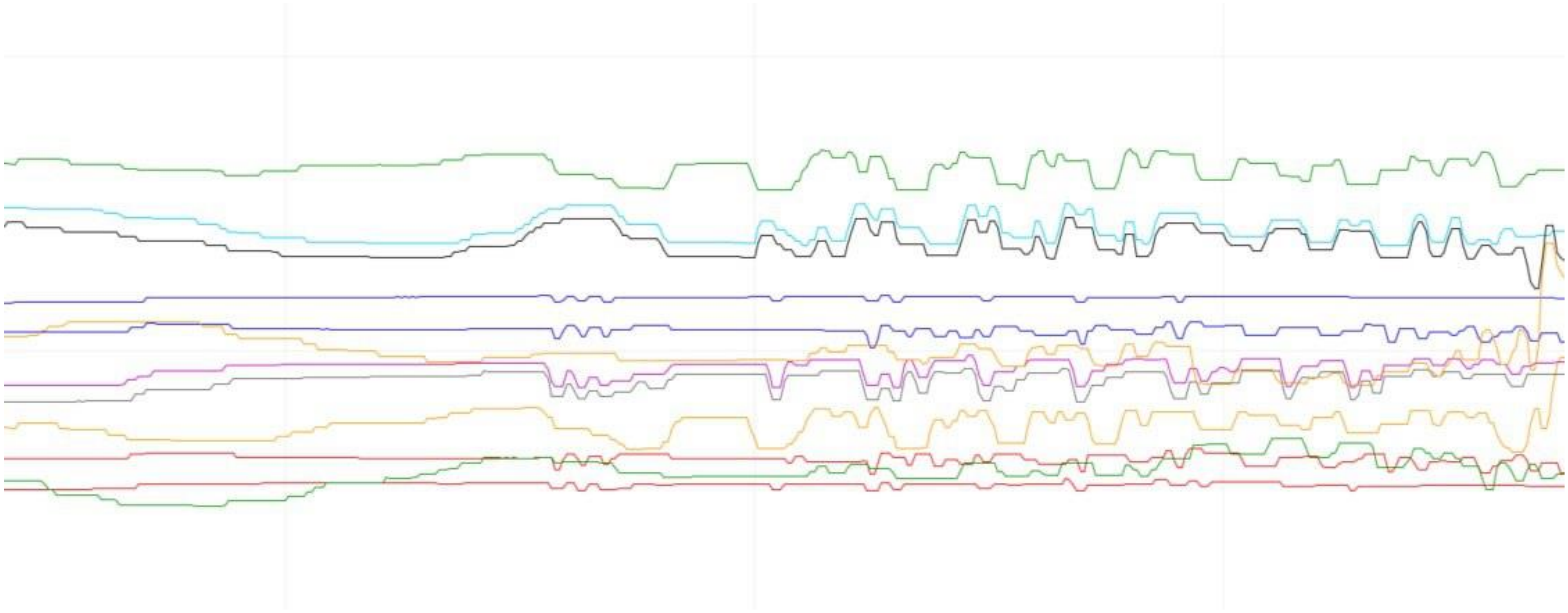
Stages of device working

1. First calibration.
2. Second calibration.
3. Operating mode.

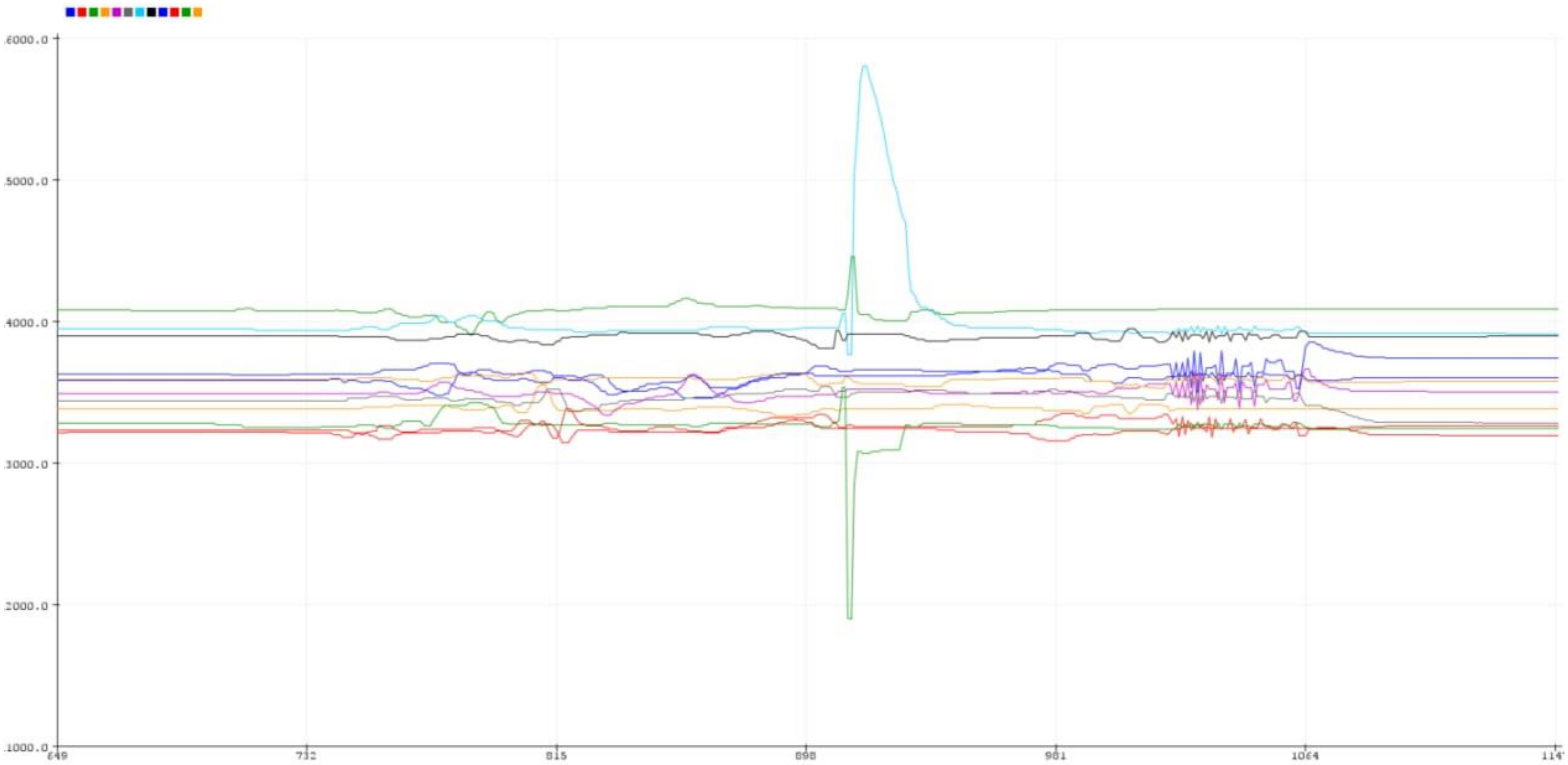
Data filtering



Graphic of magnetic field

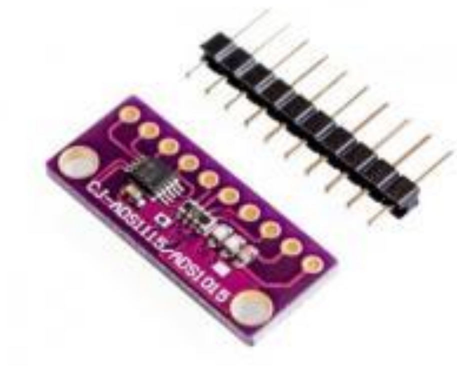


Graphic of magnetic field

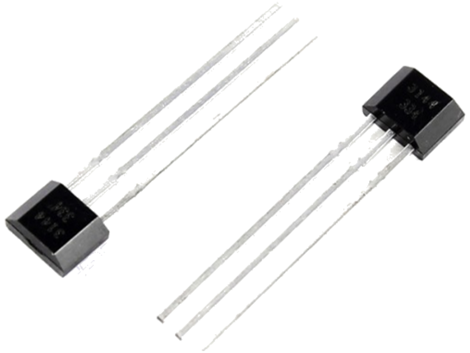


The main components of the device

STM32F103C8T6
(BluePill)



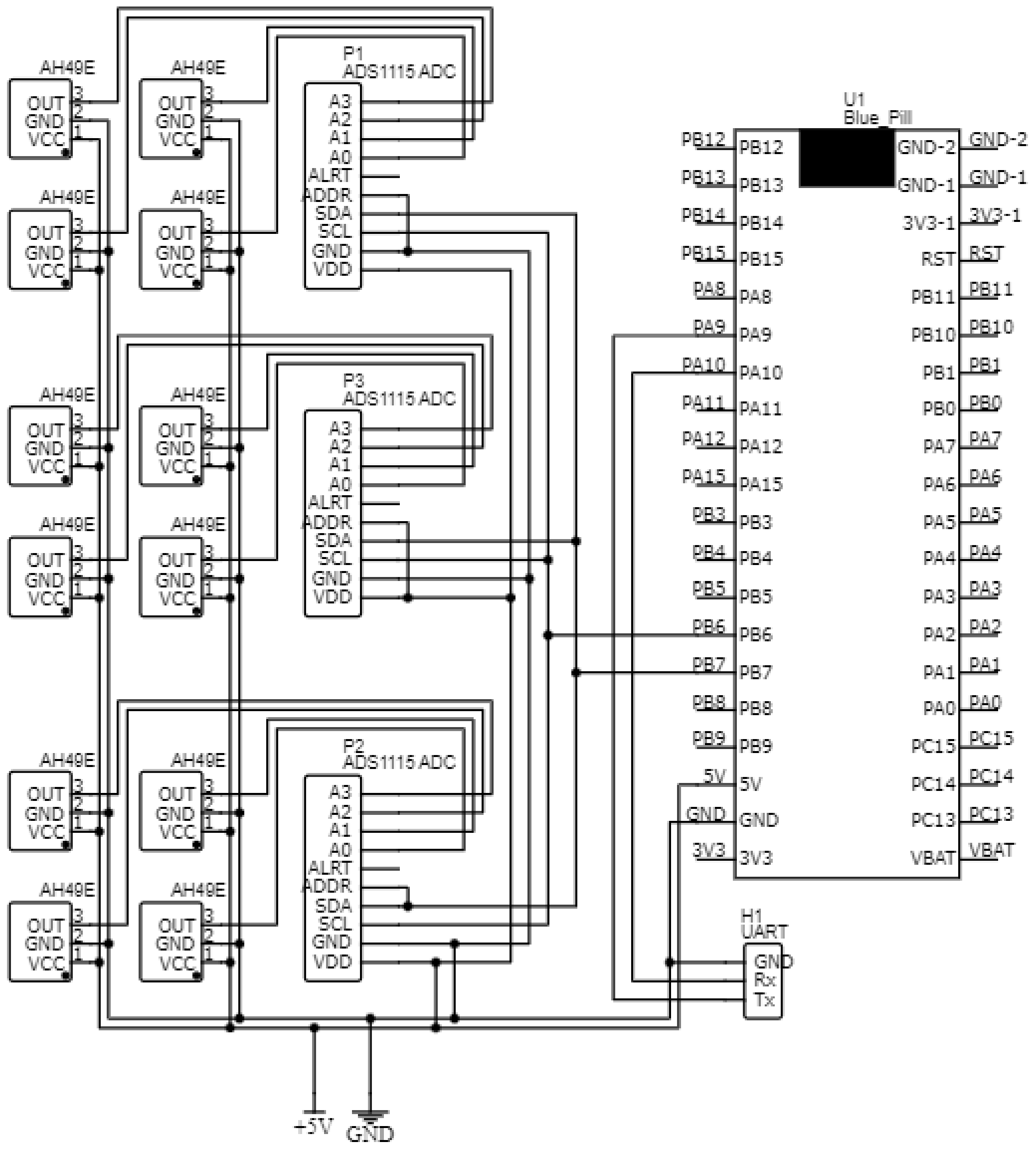
ADS1117



AH49E

USB-UART convertor
(FT232)

Device schematics



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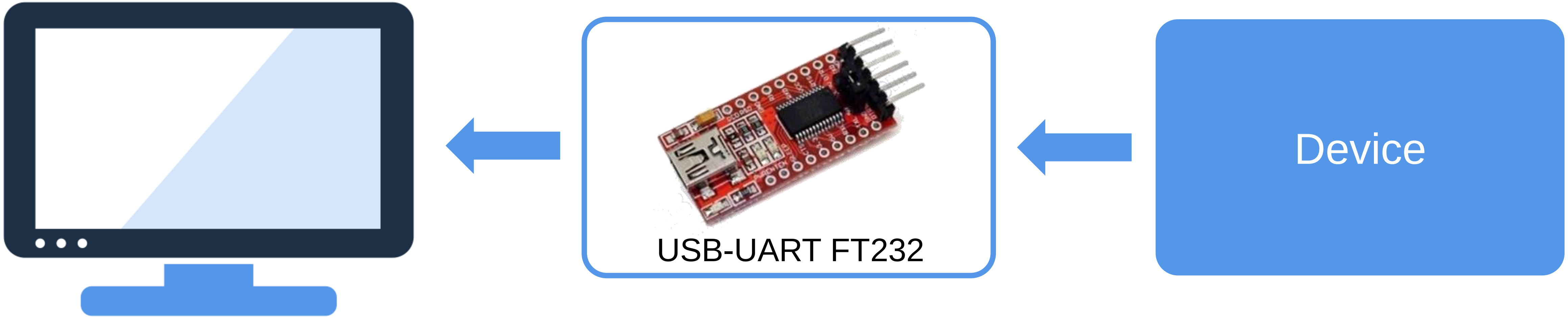
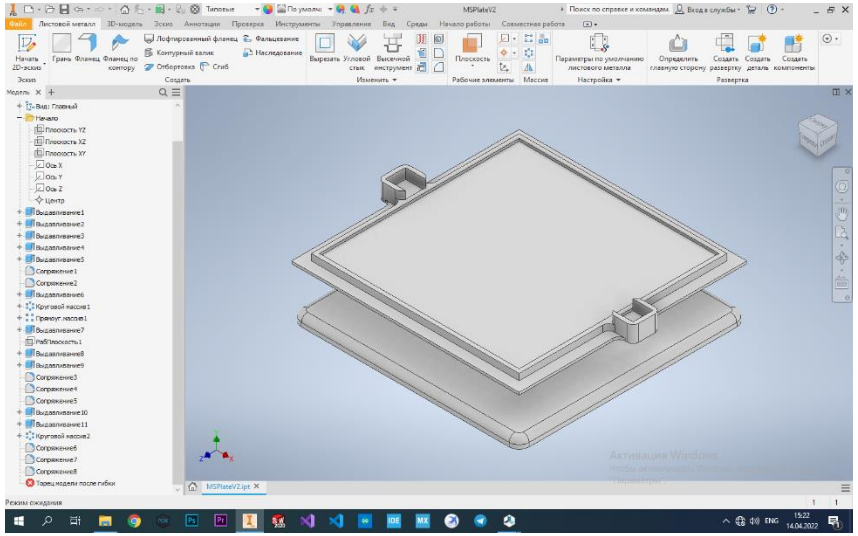
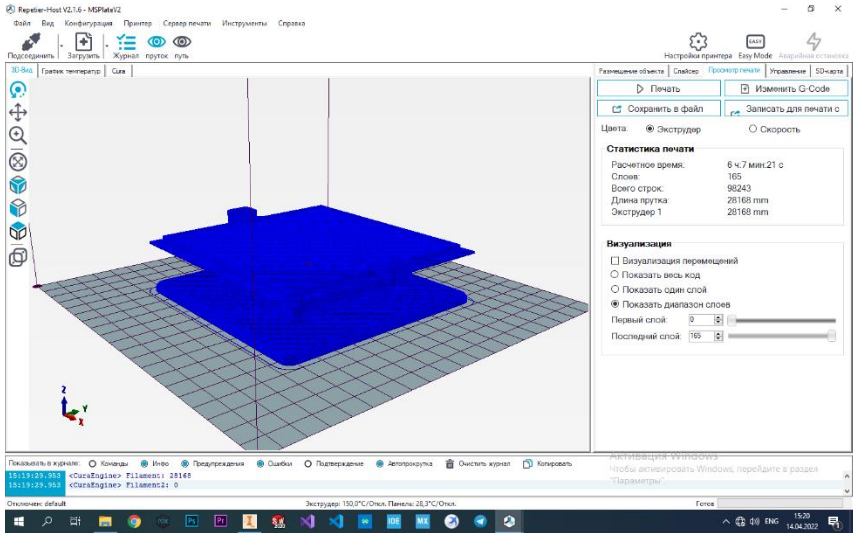
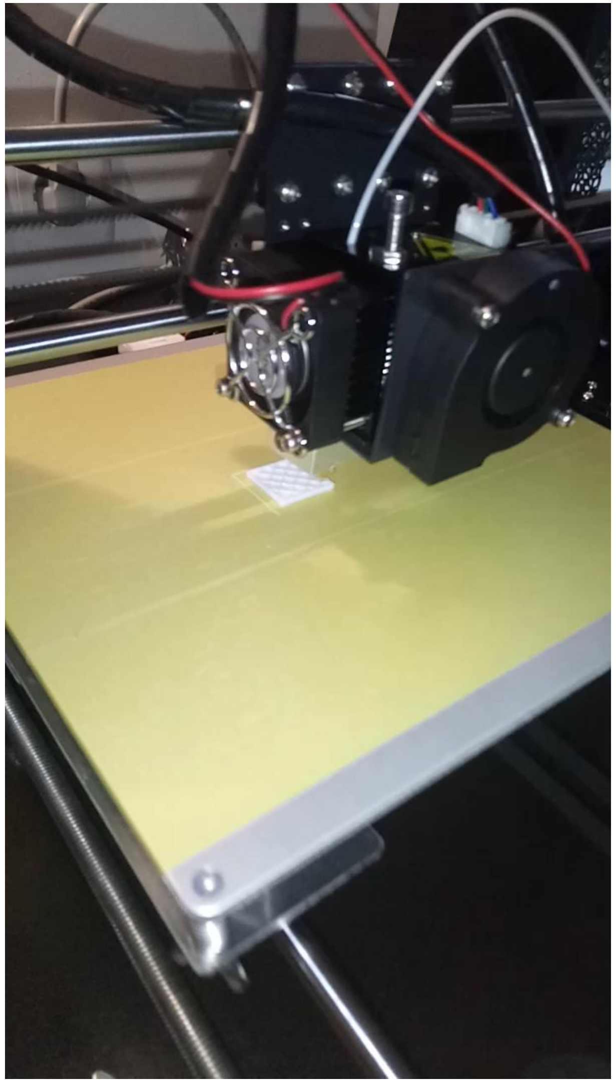
The principle of operation



Designing of device construction







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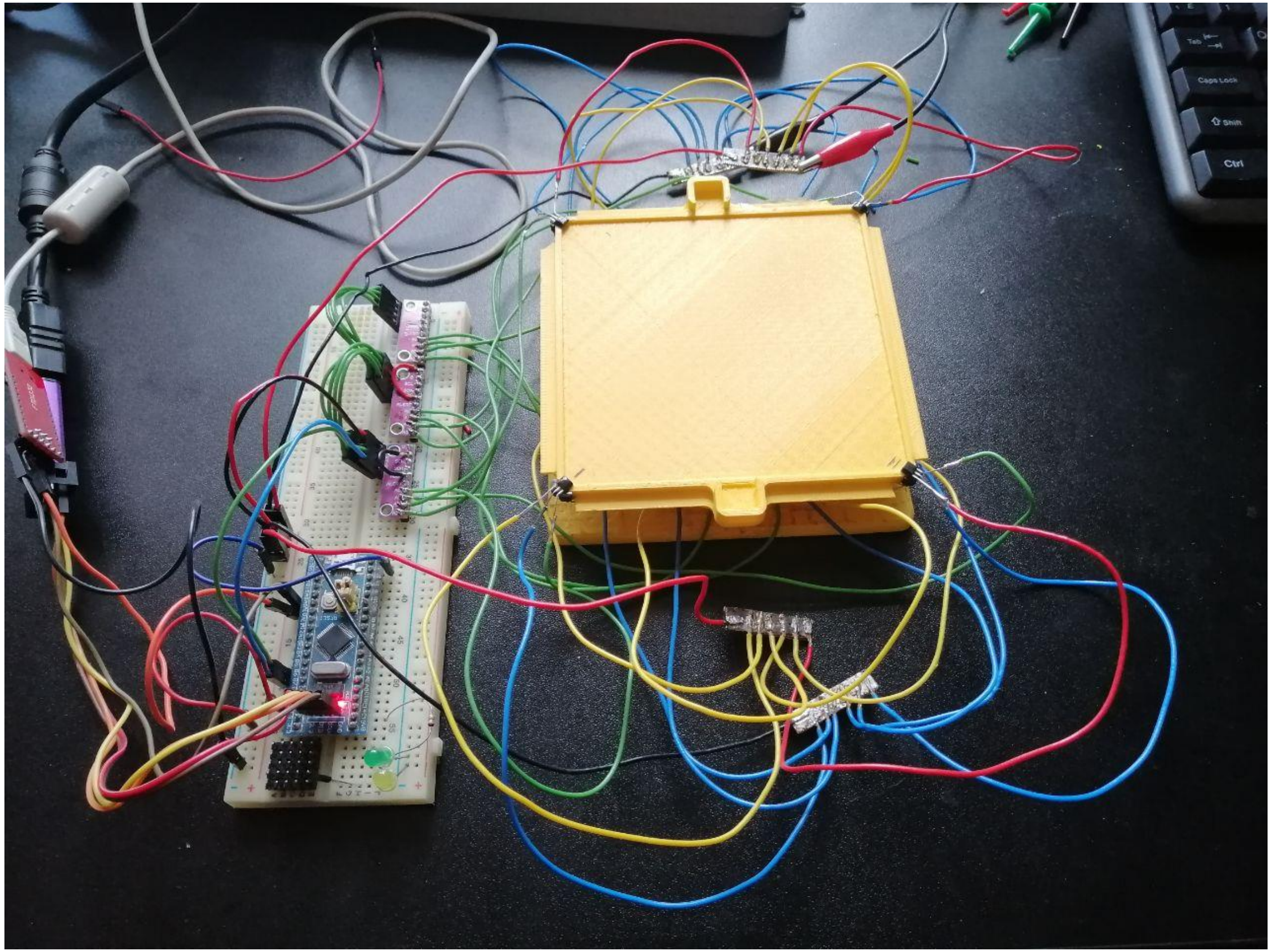
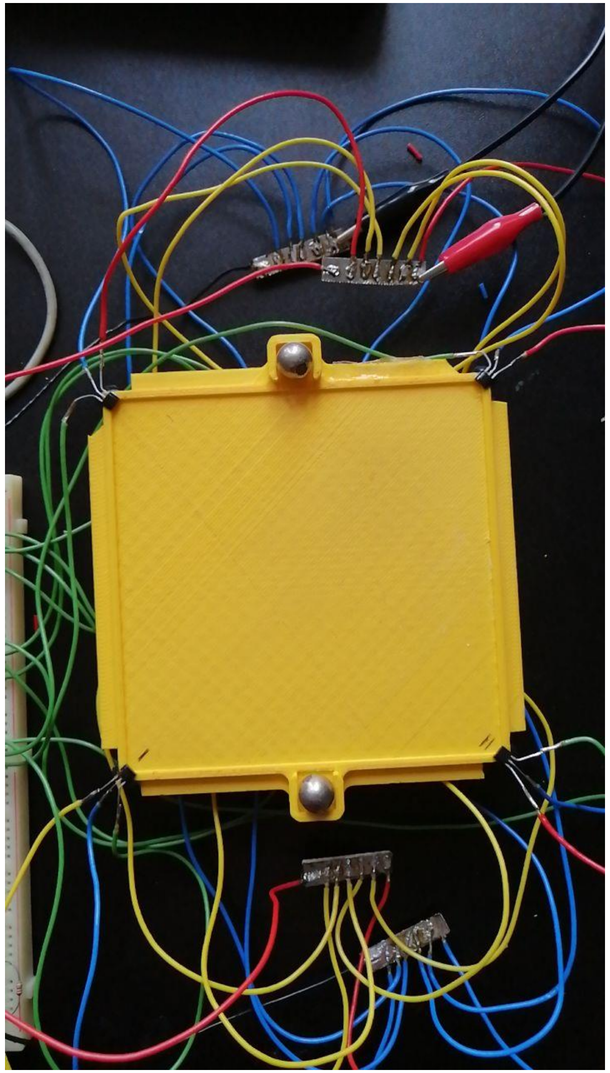
Device appearance





Device for experimental determination position of two magnetic balls

Prospects for development and improvement of the device

1. Improve the hardware using better quality parts to increase the accuracy and frequency of recording values.

2. Develop a new device with a precise ball positioning mechanism to improve calibration results.

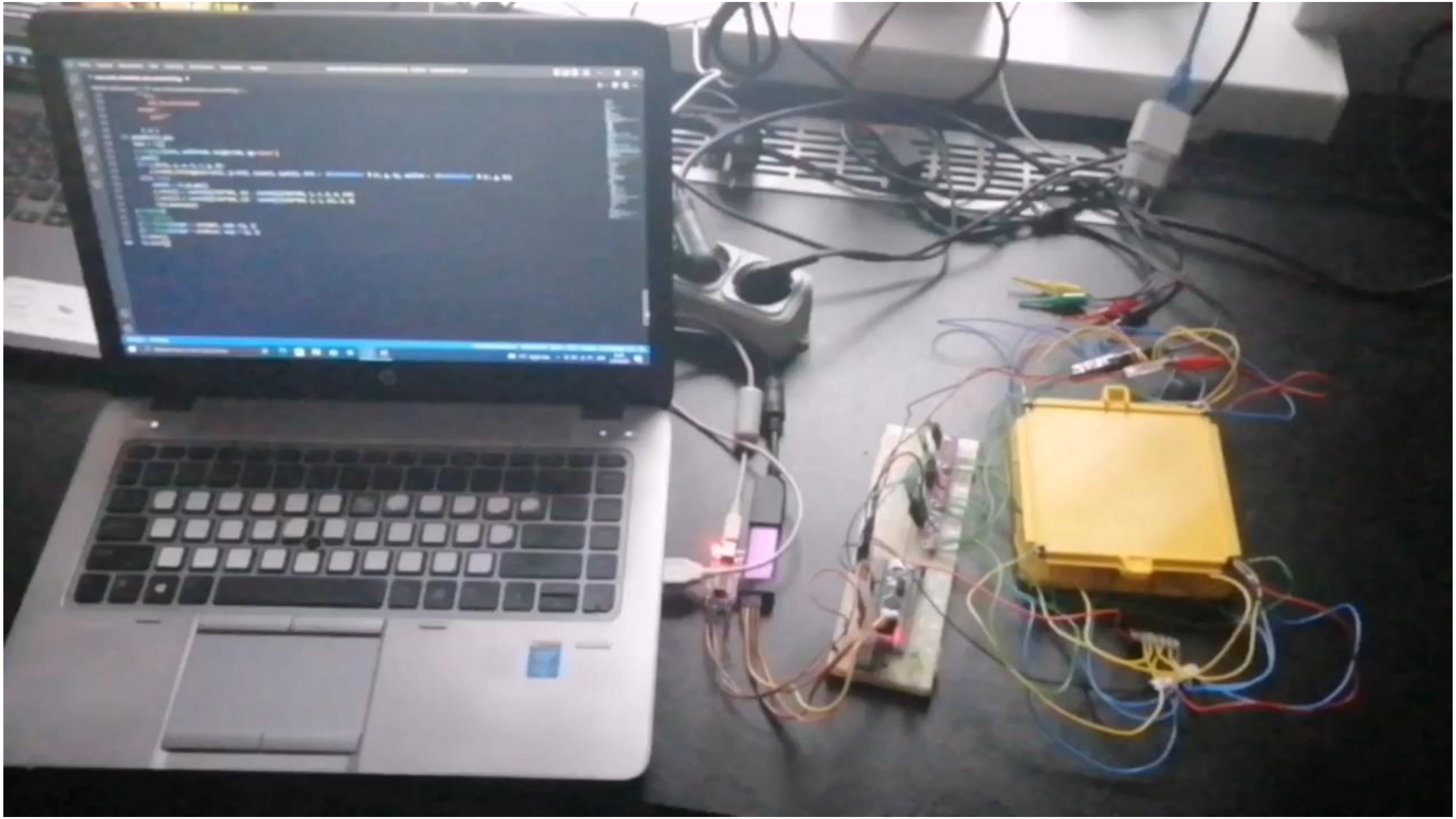
3. Improve the project as a means of feedback for its integration into the positioning system of magnetic objects using electromagnets.

Conclusions

1. Developed computer simulations based on our theory able to provide information about the laws of motion of magnetic balls.

2. Created a device that determines the position of magnetic balls allows you to experimentally test our proposed theory.

3. A further project development strategy has been identified to improve the device, namely to increase the accuracy and frequency of data recording.



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Thanks for your attention!