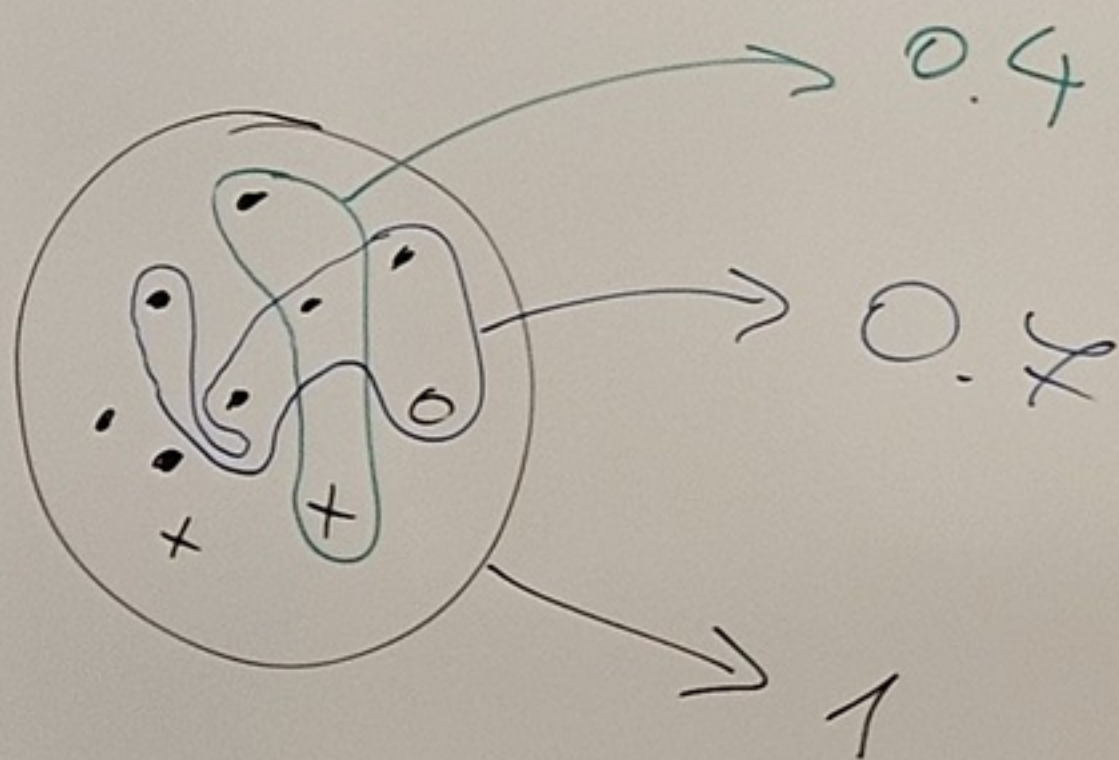


uczenie maszynowe

$f(x)$

zmienna losowa



artificial intelligence

CiA

z

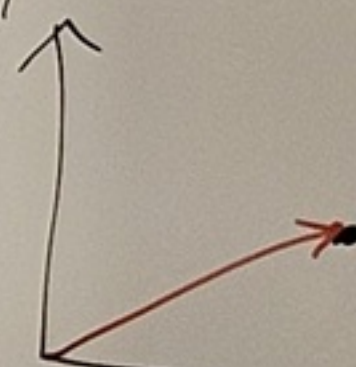
dobrze

Kościu

piwos

liczba zespolone

KOTY



$$(2K+3P) \quad (-K+P)$$

$$\begin{bmatrix} 2 \\ 3 \end{bmatrix} + \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

$$(2+3P) \quad (-1+P)$$

$$(2+3i) \cdot (-1+i)$$

$$-2+2i-3i+3i^2$$

$$i^2 = -1$$

$$-2+2i-3i-3$$

$$-2-3+2i-3i$$
$$-5-i$$

przewidywanie

pie

dowó

$$(a + \textcolor{red}{b}i) + (c + \textcolor{red}{d}i) = \\ = a + c + (\textcolor{red}{b} + \textcolor{red}{d})i$$

$$\frac{(a + bi)}{c + di} \cdot \frac{(c - di)}{c - di} =$$

$$c^2 - d^2 i^2 = c^2 + d^2$$

$$\begin{bmatrix} a & -b \\ b & a \end{bmatrix} + \begin{bmatrix} c & -d \\ d & c \end{bmatrix} =$$

Reprezentagja: $\begin{bmatrix} 2 \\ 3 \end{bmatrix}$
 $\underbrace{a + bi}$

$$\begin{bmatrix} a+c & -b-d \\ b+d & a+c \end{bmatrix} = \begin{bmatrix} a+c & -(b+d) \\ b+d & a+c \end{bmatrix}$$

$$\begin{bmatrix} a & -b \\ b & a \end{bmatrix} \approx \begin{bmatrix} \text{☹} & -\text{☹} \\ \text{☹} & \text{☹} \end{bmatrix}$$

$$i^2 = -1$$

$$\begin{aligned}(a + bi)(c + di) &= \\ ac + adi + bdi^2 + bci &= \\ = ac + adi - bd + bci &= \\ = ac - bd + (ad + bc)i\end{aligned}$$

$$\begin{aligned}ac + adi + bi + bdi^2 &= \\ = ac - bd + (ad + bc)i\end{aligned}$$

$$(a + bi) \cdot (c + di) = ac - bd + (ad + bc)i$$

$$\begin{bmatrix} c & -d \\ d & c \end{bmatrix}$$

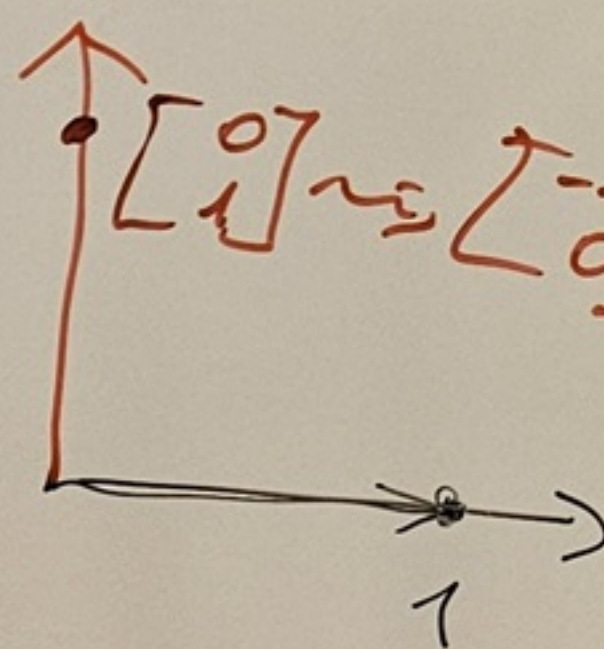
$$\begin{bmatrix} a & -b \\ b & a \end{bmatrix} \begin{bmatrix} ac - bd & -ad - bc \\ bc + ad & -bd + ac \end{bmatrix} = \begin{bmatrix} ac - bd & -(ad + bc) \\ ad + bc & ac - bd \end{bmatrix}$$

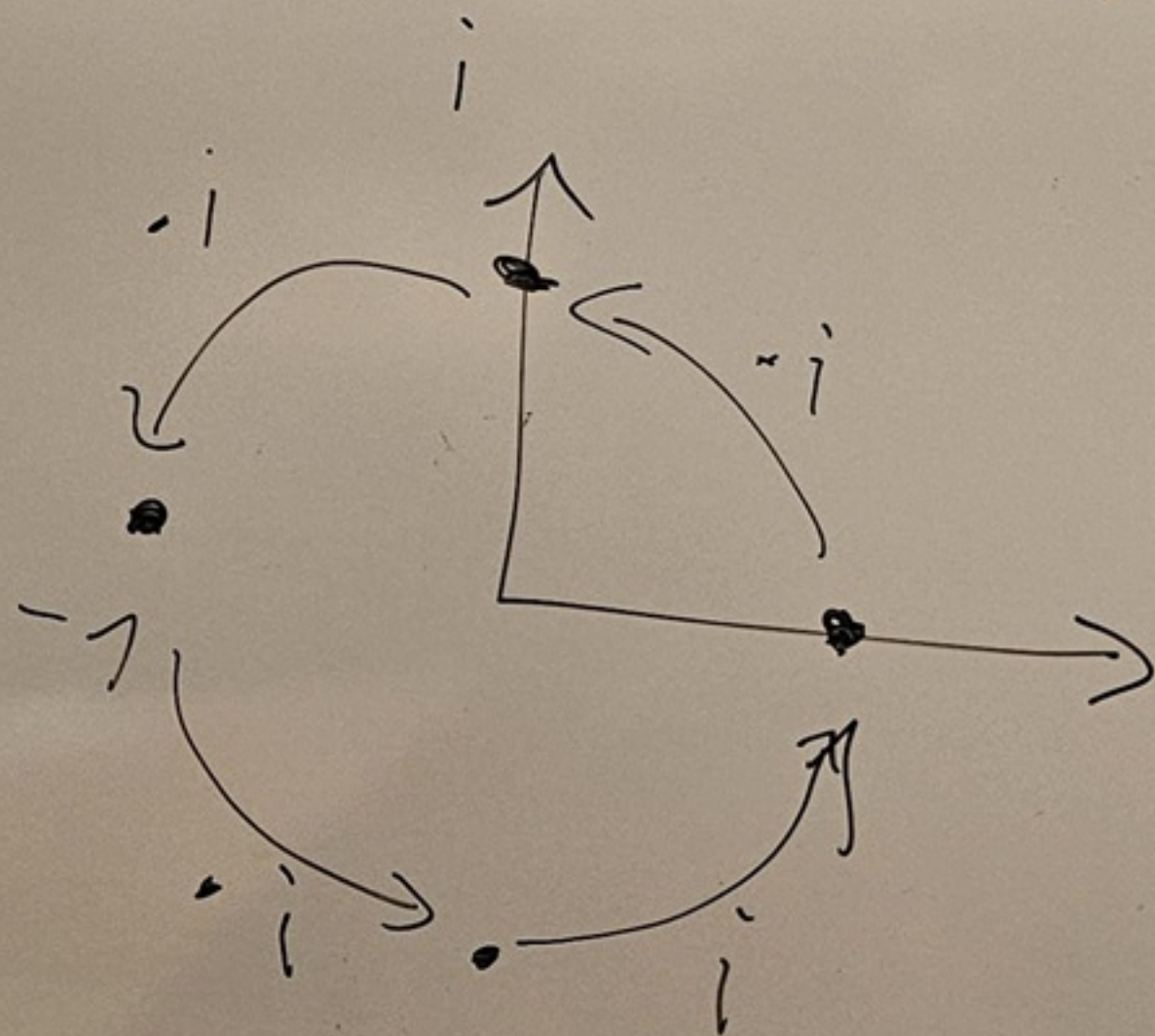
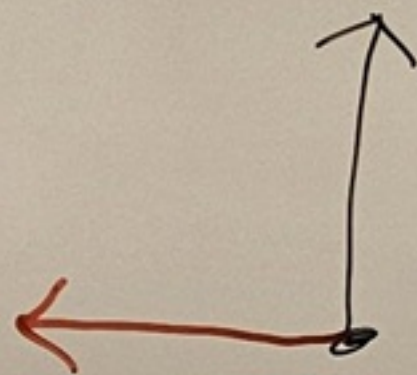
$$a + bi$$

$$i^2 = -1$$

$$0 + i$$

$$\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$$

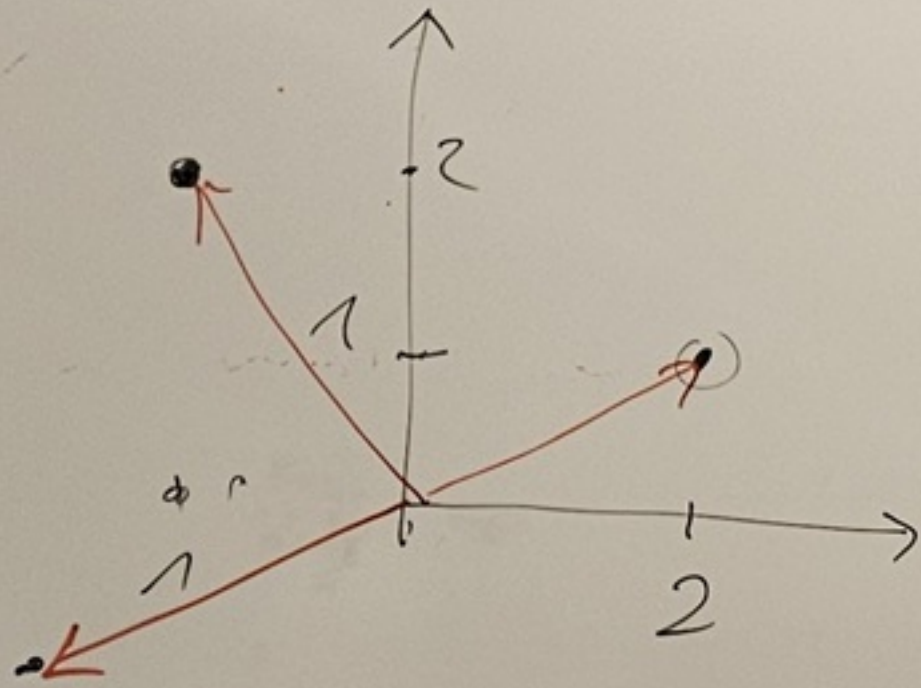
$$\begin{bmatrix} 0 \\ i \end{bmatrix} \sim \begin{bmatrix} -1 \\ 0 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} \sim \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$




$$1 + 0i$$

$$1 \cdot i = i$$

$$i \cdot i = -1$$



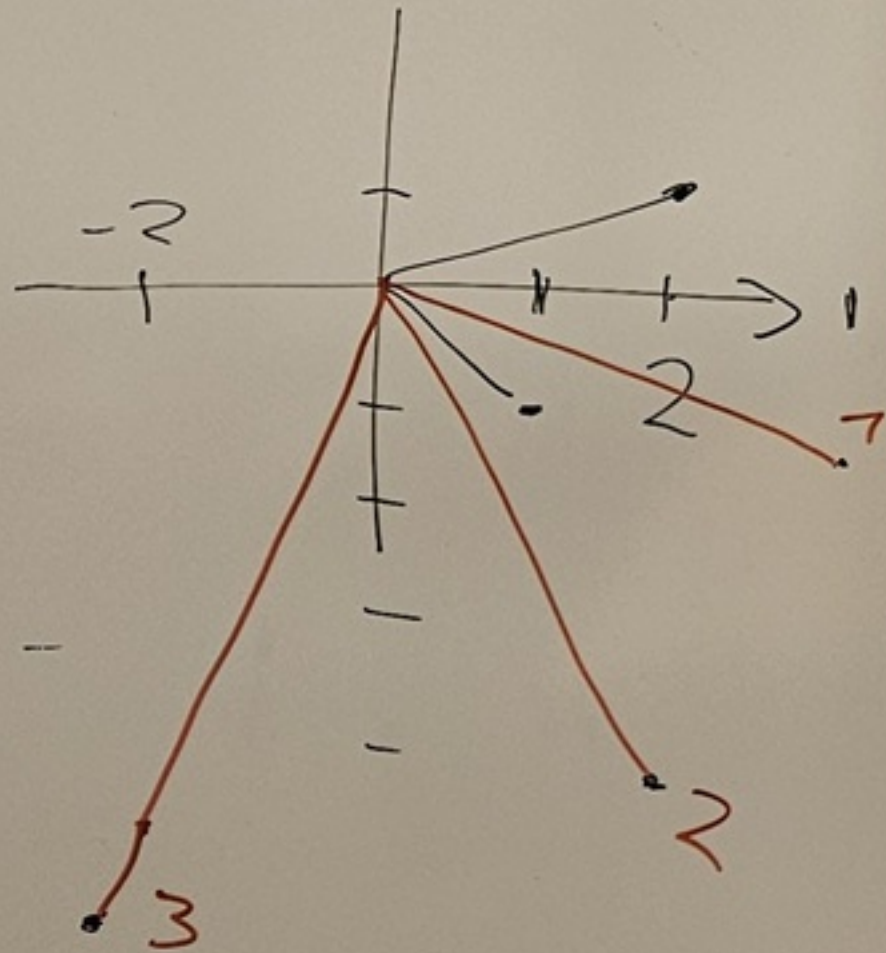
$$(2+i) \cdot i = 2i - 1 = -1 + 2i$$

$$(-1+2i)i = -2 - i$$

$$(2+i)(1-i) = 3 - i$$

$$(3-i)(1-i) = 2 - 4i$$

$$(2-4i)(1-i) = -2 - 6i$$

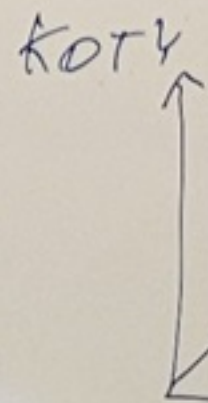


$$\text{pocz. } (1-i)$$

$$\text{pocz. } (1-i)^2$$

$$\text{pocz. } (1-i)^3$$

$$i^2 = -1$$



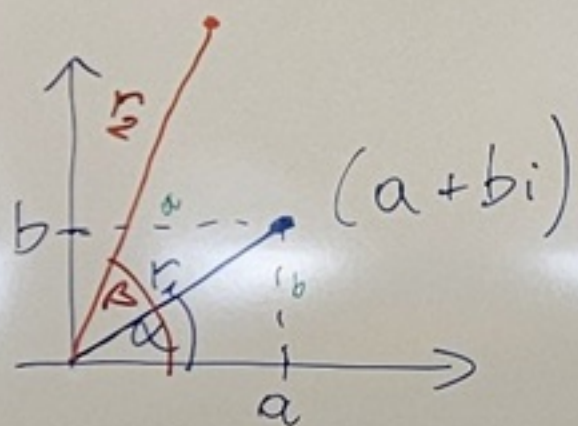
$$\begin{bmatrix} a \\ b \end{bmatrix} + \begin{bmatrix} c \\ d \end{bmatrix}$$

$$(aP + bK)(cP + dK)$$

$$(a + bi)(c + di) = \underbrace{i^2 = -1}$$

$$\begin{bmatrix} a & -b \\ b & a \end{bmatrix}$$

$$z \leftarrow z^2$$



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

$$\sin \alpha = \frac{b}{r} \Rightarrow b = r \sin \alpha$$

$$\cos \alpha = \frac{a}{r} \Rightarrow a = r \cos \alpha$$

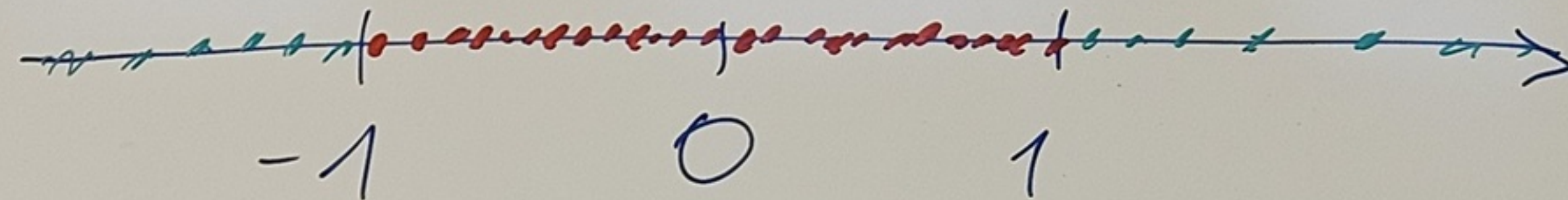
$$r \cos \alpha + r \sin \alpha i = r(\cos \alpha + i \sin \alpha)$$

$$z_1 = r_1(\cos \alpha + i \sin \alpha)$$

$$z_2 = r_2(\cos \beta + i \sin \beta)$$

$$z_1 \cdot z_2 = r_1 r_2 \left[\cos \alpha \cdot \cos \beta - \sin \alpha \sin \beta + i(\cos \alpha \sin \beta + \sin \alpha \cos \beta) \right]$$

$$z_1 \cdot z_2 = r_1 r_2 \left[\text{tędy wzór} \rightarrow \sin(\alpha + \beta) \text{ i } \cos(\alpha + \beta) \right]$$



$$z_0 = \frac{1}{2}$$

$$z_1 = \frac{1}{4}$$

$$z_2 = \frac{1}{16}$$

$$z_3 = \frac{1}{256}$$

$$z_0 = 2$$

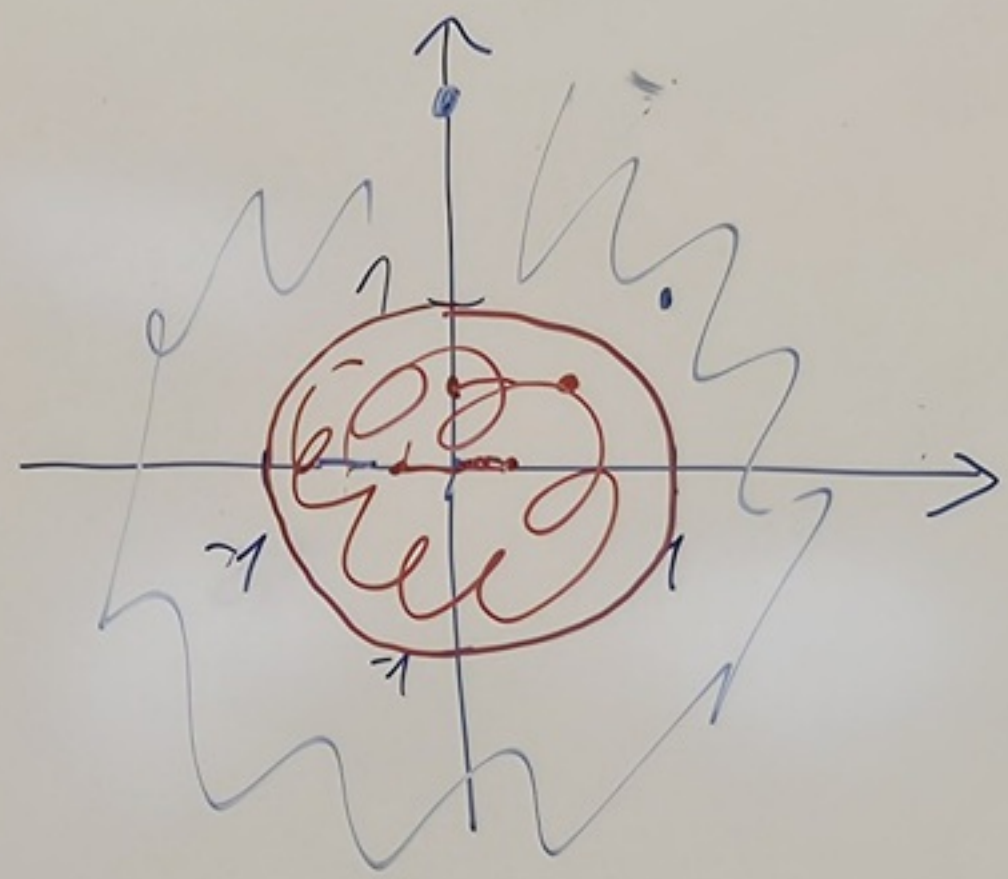
$$z_1 = 4$$

$$z_2 = 16$$

$$z_3 = 256$$

$$z \leftarrow z^2 + 1$$

ucieczka
iteracjami



$$z \leftarrow z^2 + z_0$$

graw dw

$$\left(\frac{1}{2} + \frac{1}{2}i\right) = \frac{1}{2}(1+i) = z_0$$

$$z_1 = \frac{1}{2}(1+i) \cdot \frac{1}{2}(1+i) = \frac{1}{2}i$$

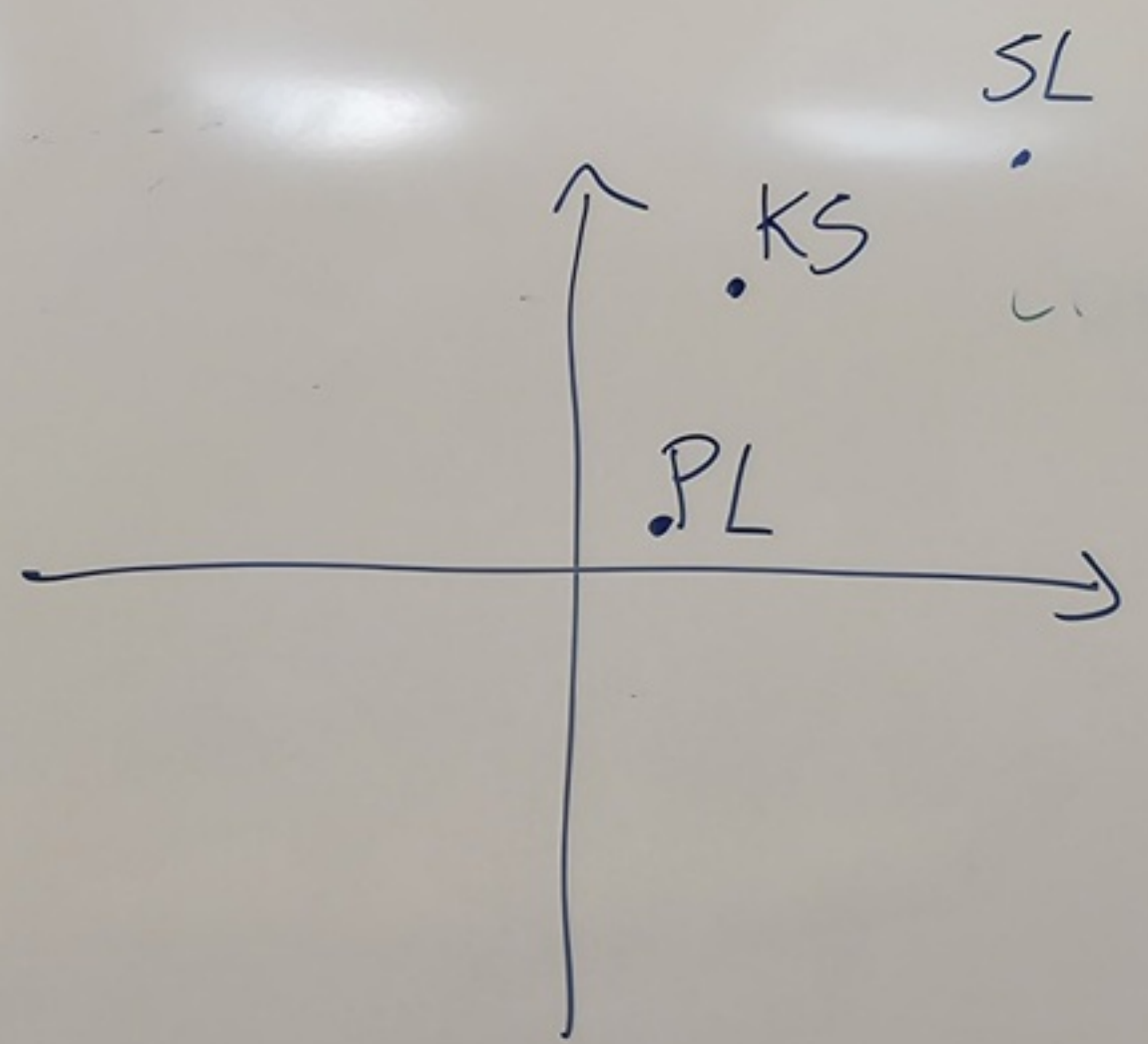
$$z_2 = \frac{1}{2}i \cdot \frac{1}{2}i = -\frac{1}{4}$$

$$z_3 = -\frac{1}{4}$$

$$(1+i) = z_0$$

$$z_1 = 2i$$

$$z_2 = 2i \cdot 2i = -4$$



$$z_0 = (1+i)$$

$$z_1 = (1+i)^2 + (1+i) = 1+3i$$

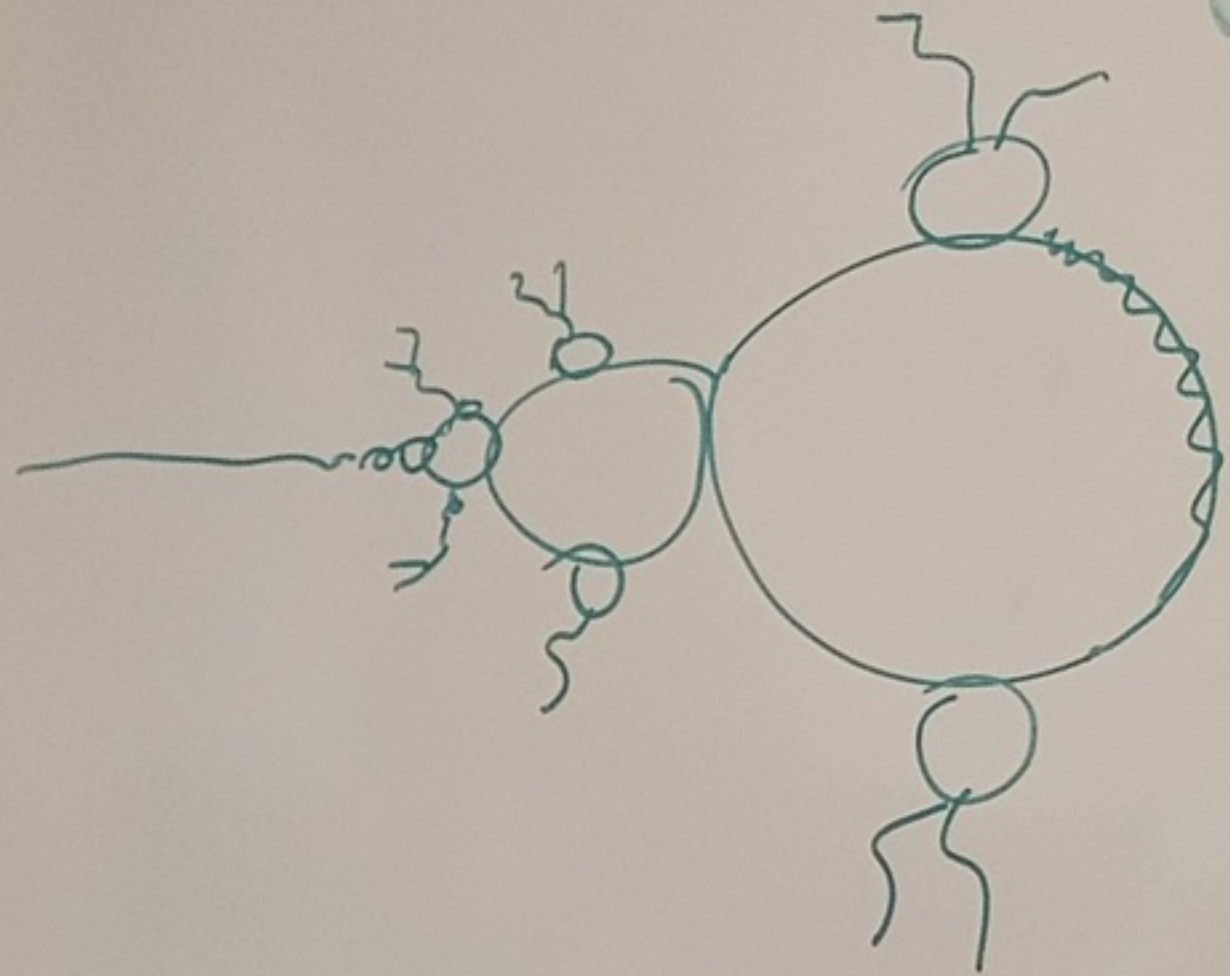
$$z_2 = (1+3i)^2 + (1+i) = -4+7i$$

$$z_3 = [-4(1-i)]^2 + (1+i)$$

Mandelbrot

Fraktal Mandelbrota

$$z \leftarrow z^2 + z_0$$



Zbiory Julii ustalona
liczba zespolona

$$z \leftarrow z^2 + p$$

n.p. $z \leftarrow z^2 + \left(\frac{1}{3} - \frac{1}{2}i\right)$