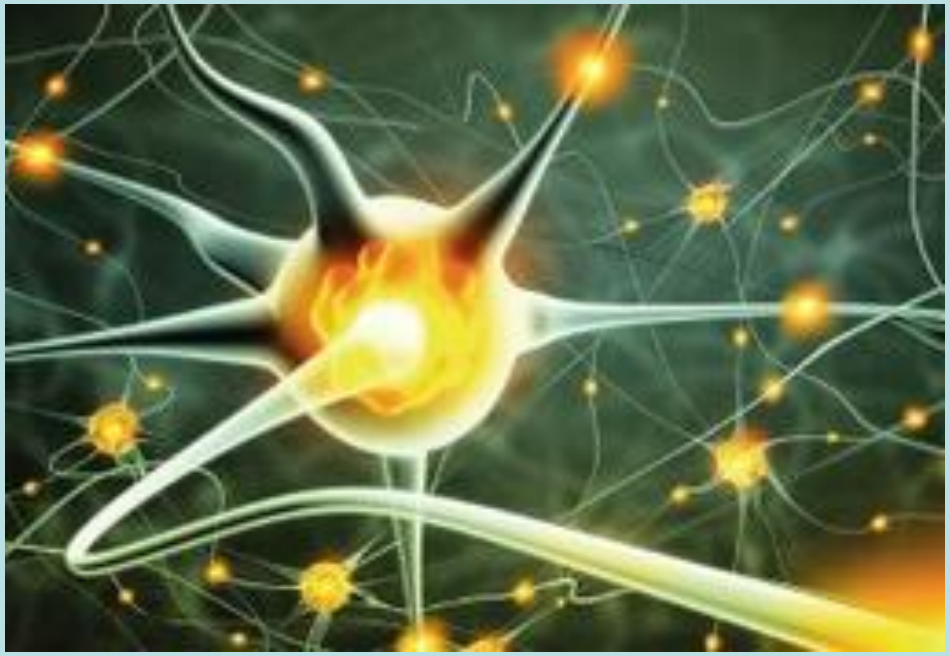
IPV Workshop: Das Gymy

Imanol Schlag



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Ziel

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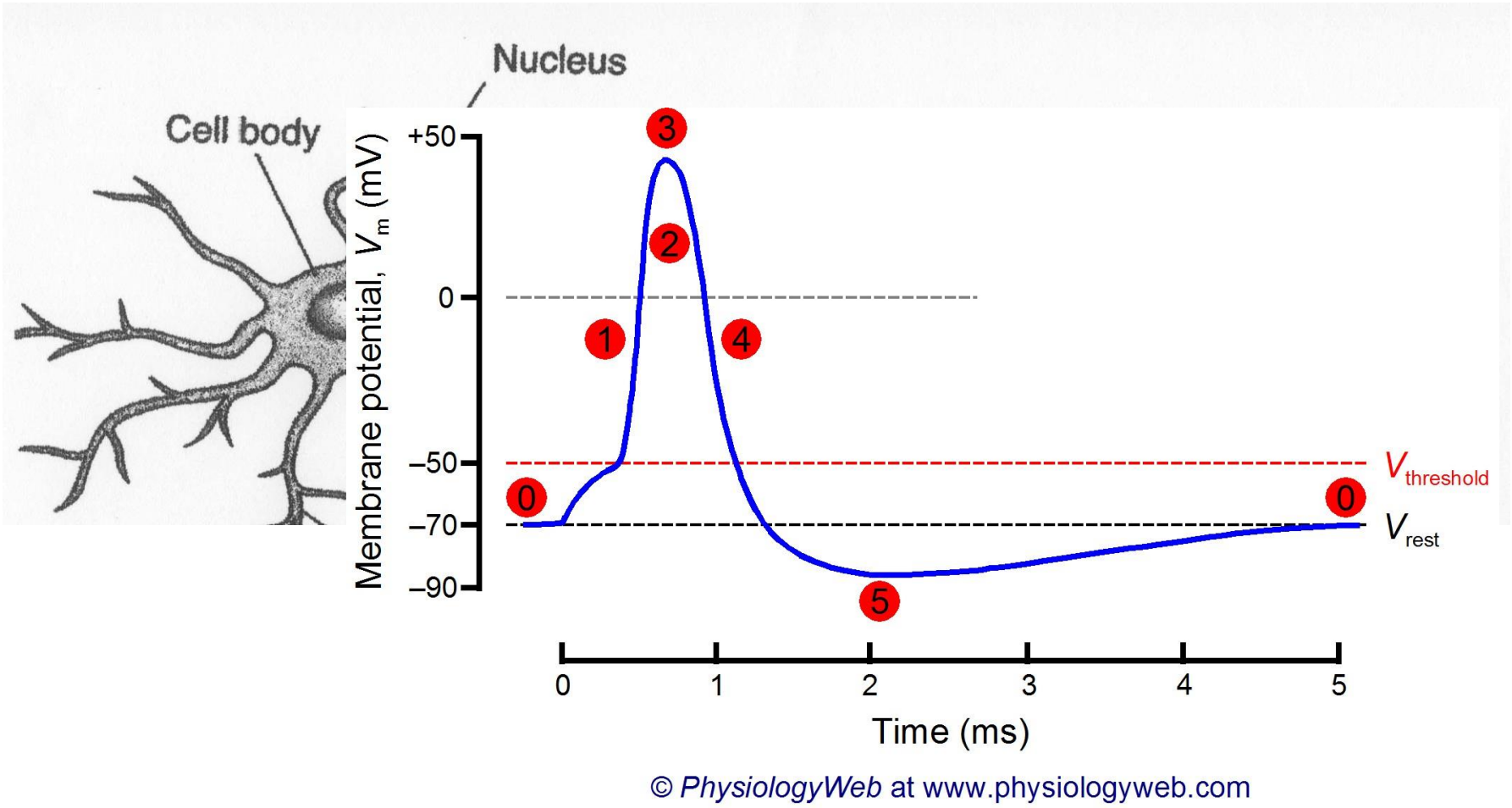
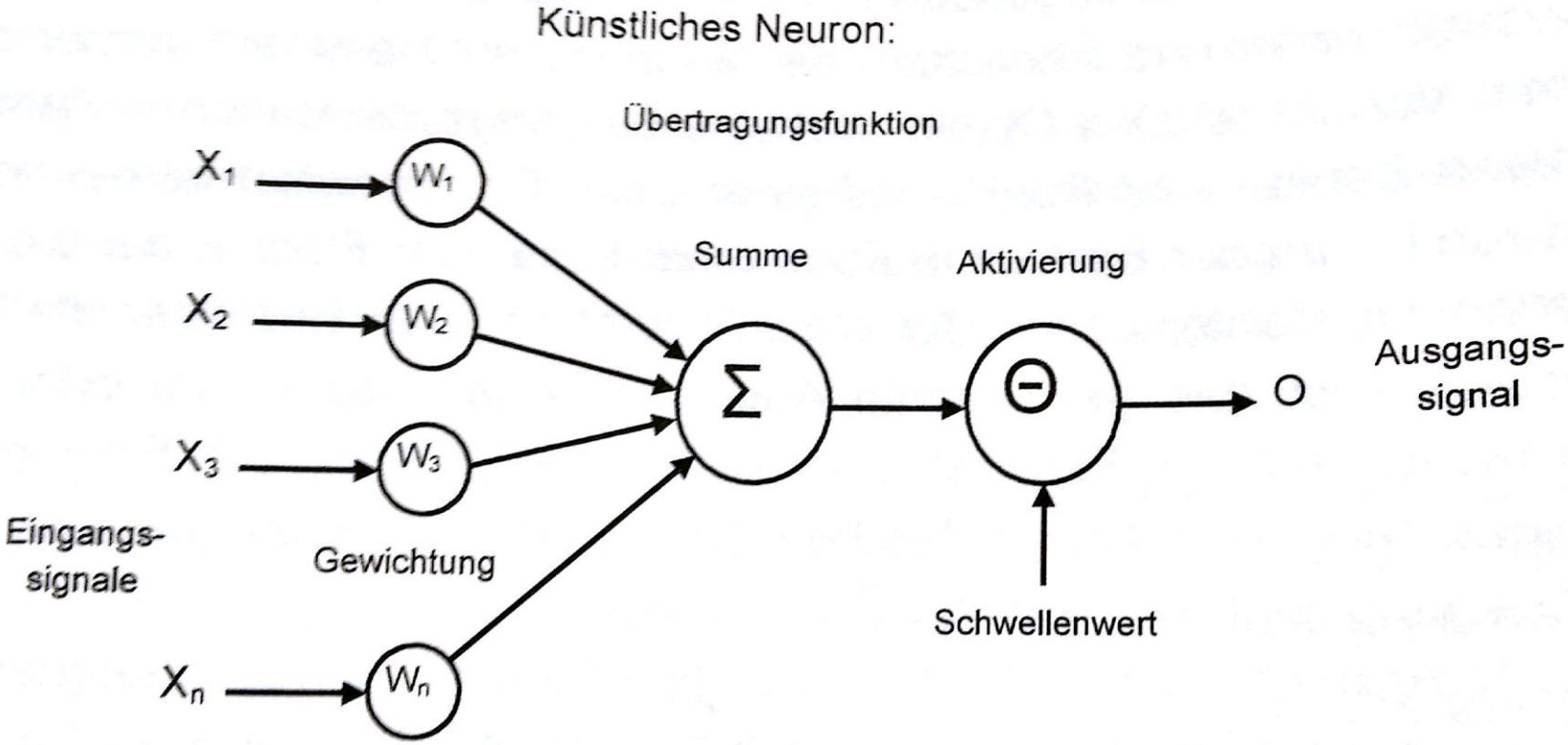
Gymy – Das Neuron



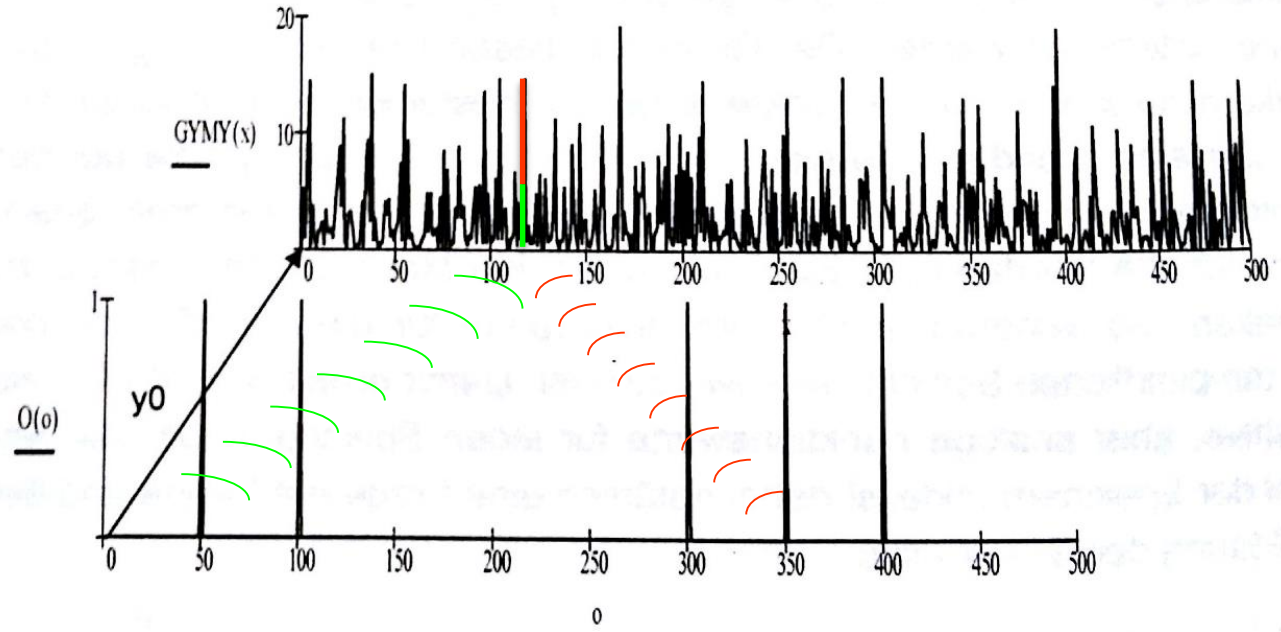
Gymy – Ein künstliches Neuron



Gymy – Das Gymy als Assoziativspeicher

Konstruktion:

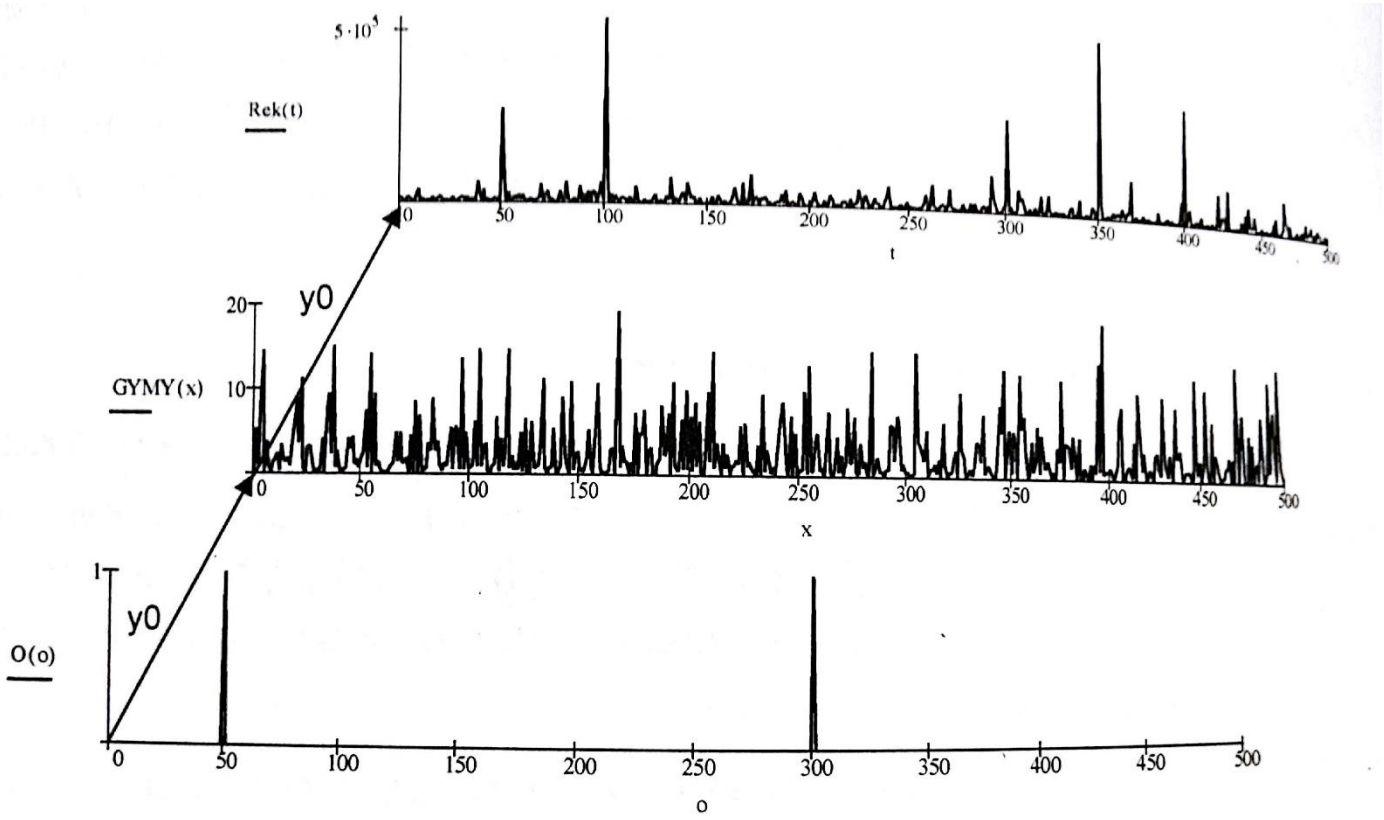
$$GYMY(x) := \left[\sum_i \cos\left[2 \cdot \frac{\pi}{q} \cdot \left[\sqrt{y0^2 + (Objekt_i - x)^2} \right] \right] \right]^2$$



Gymy – Das Gymy als Assoziativspeicher

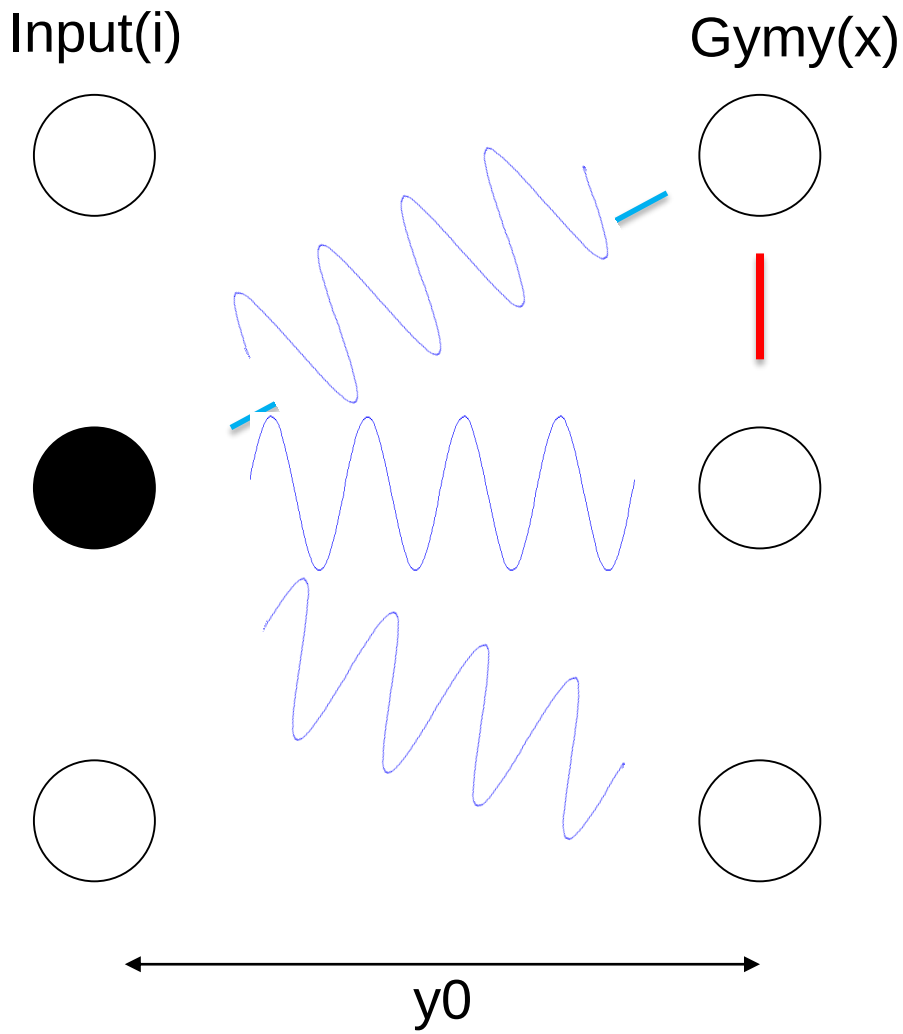
Rekonstruktion:

$$Rek(t) := \left[\sum_{i} \sum_{x} GYMY(x) \cdot \cos\left[2 \cdot \frac{\pi}{q} \cdot \left[\sqrt{y0^2 + (t-x)^2} + \sqrt{y0^2 + \left(x - Objekt_i\right)^2} \right] \right] \right]^2$$



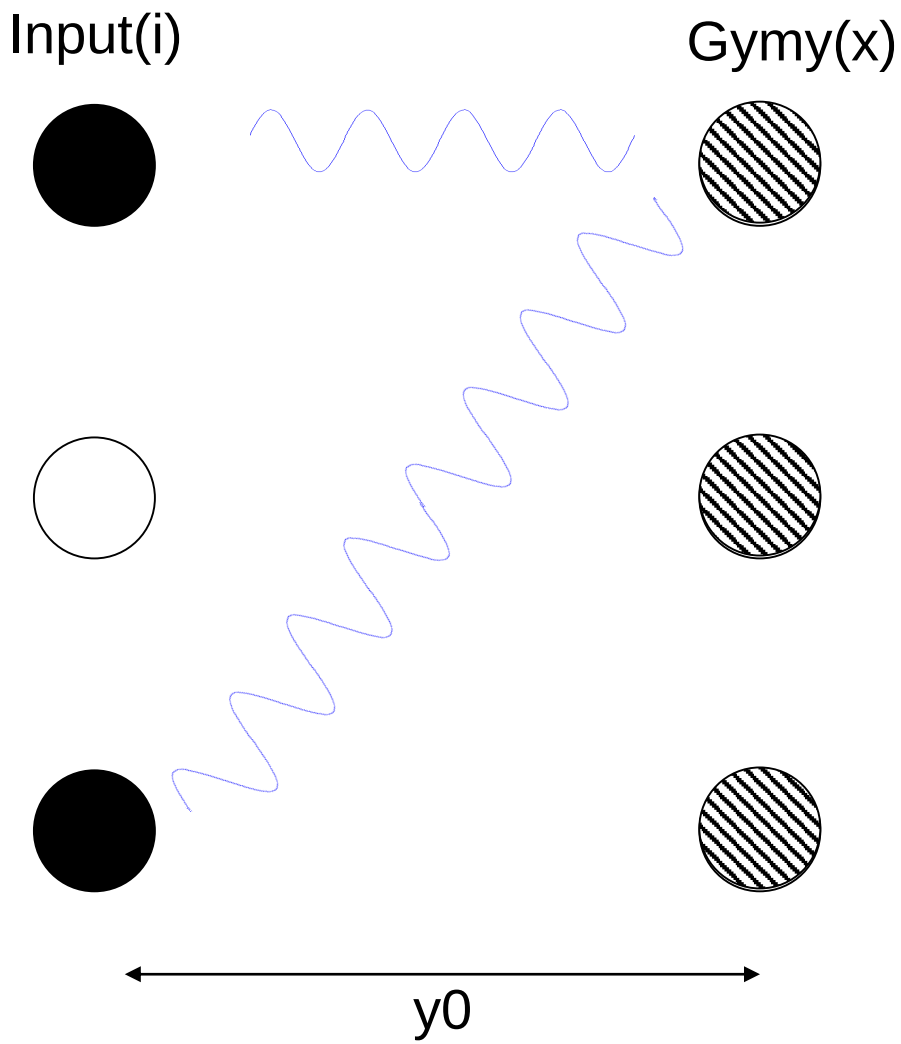
$$GYMY(x) := \left[\sum_i \cos\left[2 \cdot \frac{\pi}{q} \cdot \left[\sqrt{y0^2 + (Objekt_i - x)^2} \right] \right] \right]^2$$

Gymy – Was passiert genau? (Konstruktion)



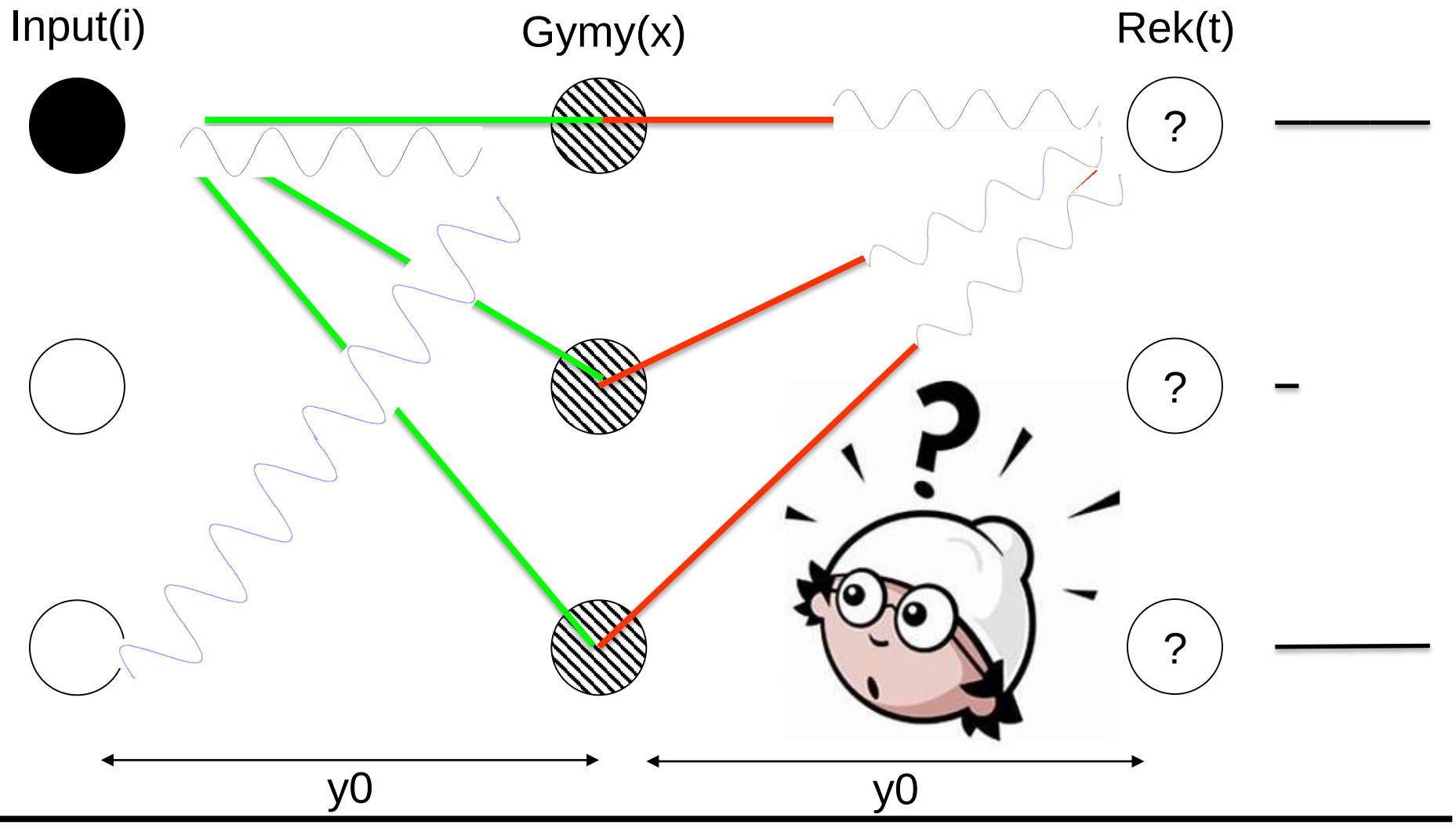
$$GYMY(x) := \left[\sum_i \cos\left[2 \cdot \frac{\pi}{q} \cdot \left\lfloor \sqrt{y0^2 + (Objekt_i - x)^2} \right\rfloor \right] \right]^2$$

Gymy – Was passiert genau? (Konstruktion)



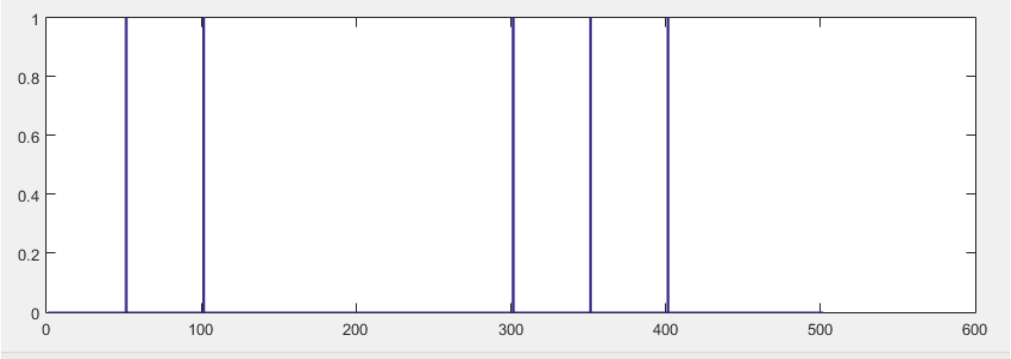
$$\mathrm{Rek}(t) := \left[\sum_i \sum_x \mathrm{GYMY}(x) \cdot \cos\left[2 \cdot \frac{\pi}{q} \cdot \left[\sqrt{y0^2 + (t-x)^2} + \sqrt{y0^2 + (x - \mathrm{Objekt}_i)^2} \right] \right] \right]^2$$

Gymy – Was passiert genau? (Rekonstruktion)

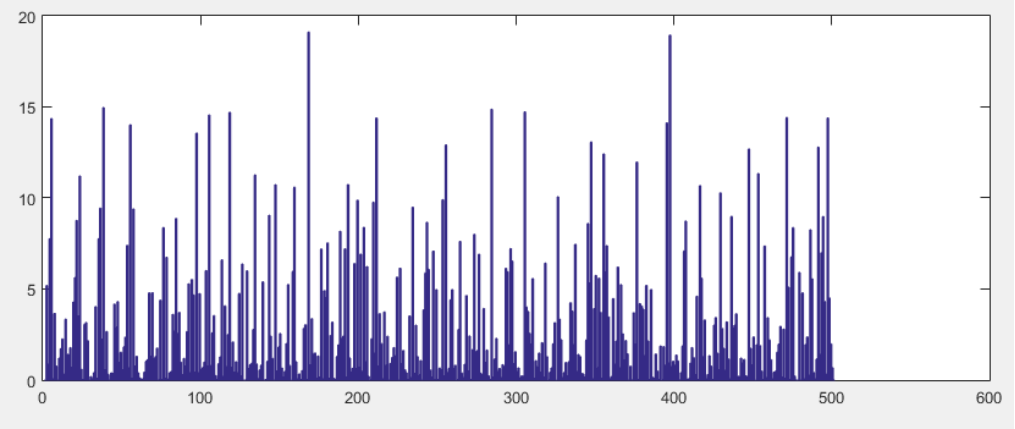


Gymy – Beispiele (1D)

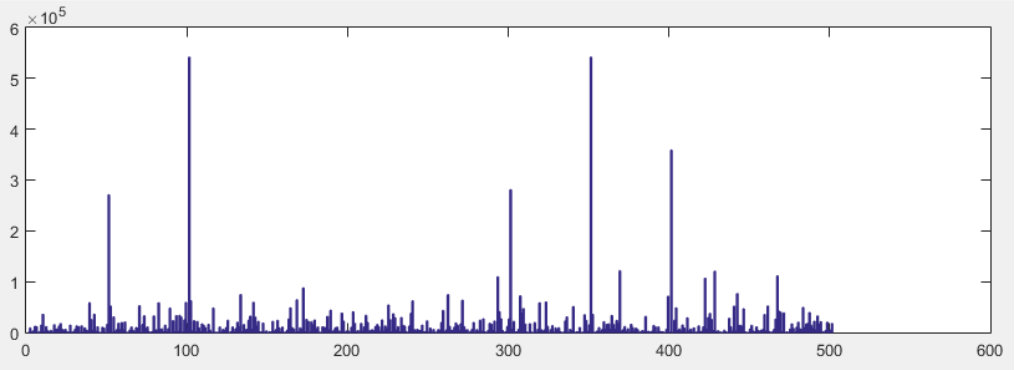
Training:
[50, 100, 300, 350, 400]



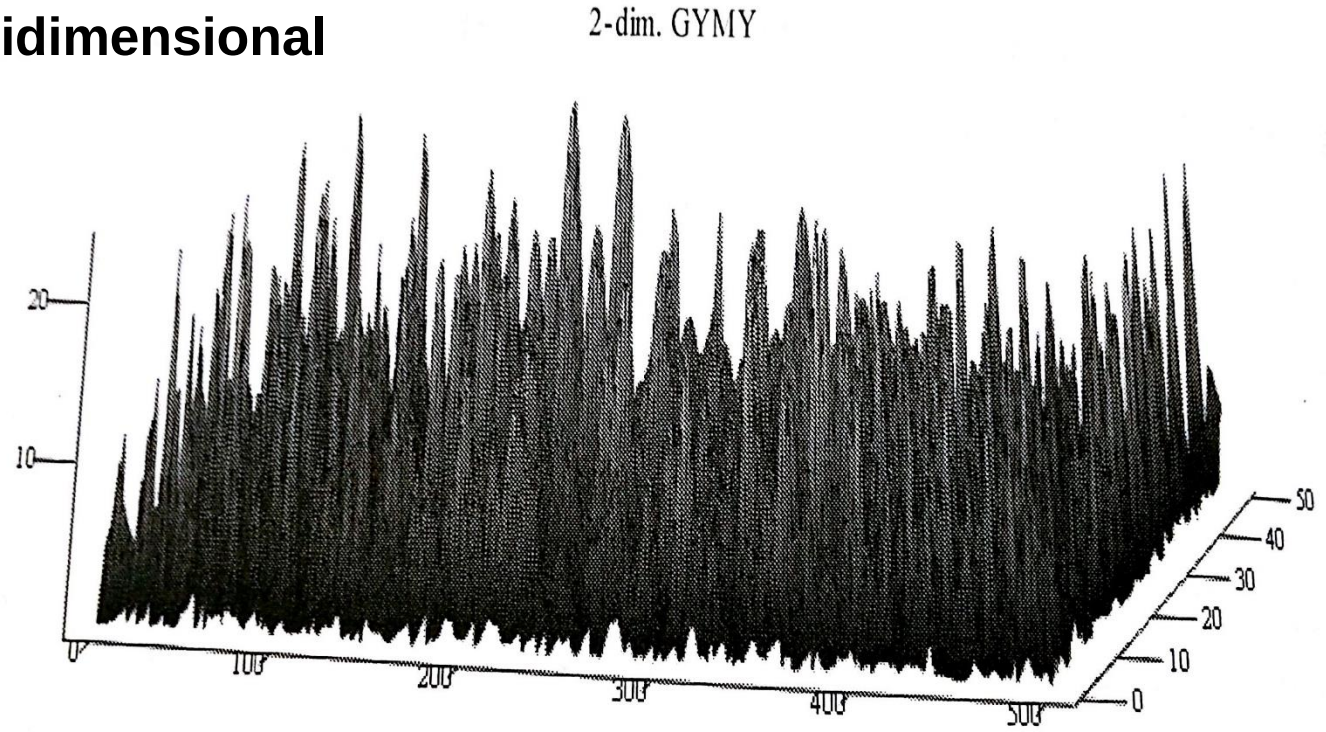
Gymy:



Rek mit [50,300]:



Gymy - zweidimensional

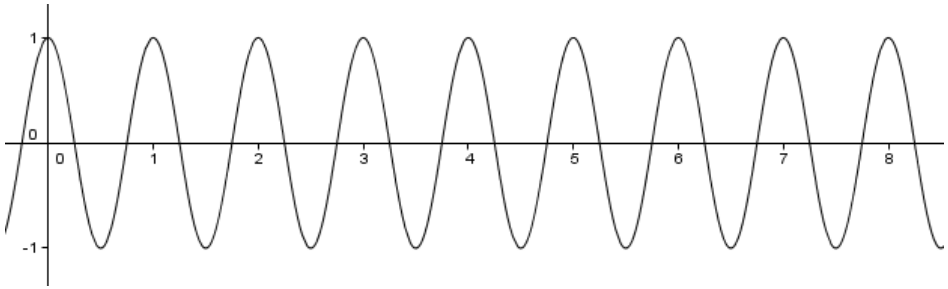


$$GYMY(x,y) := \left[\sum_{i=0}^{4} \cos\left[2 \cdot \frac{\pi}{q} \cdot \left[\sqrt{(y0+y)^2 + \left[x - \left(Objekt_j \right) \right]^2} \right] \right] \right]^2$$

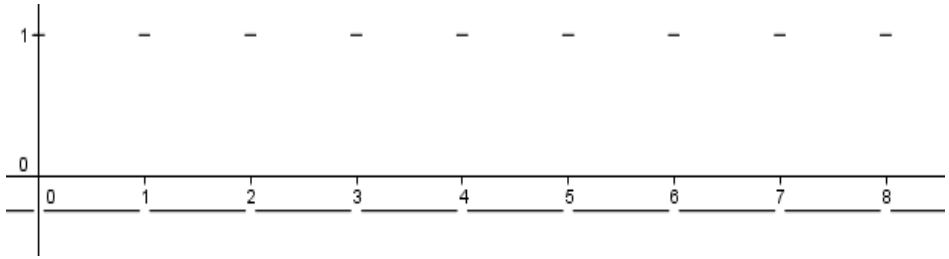
$$Rek(t) := \left[\sum_{i} \sum_{x} \sum_{y} GYMY(x,y) \cdot \cos\left[2 \cdot \frac{\pi}{q} \cdot \left[\sqrt{(y0+y)^2 + (t-x)^2} + \sqrt{(y0+y)^2 + \left(x - Objekt_j \right)^2} \right] \right] \right]^2$$

Gymy – Digitalisierung des Signals

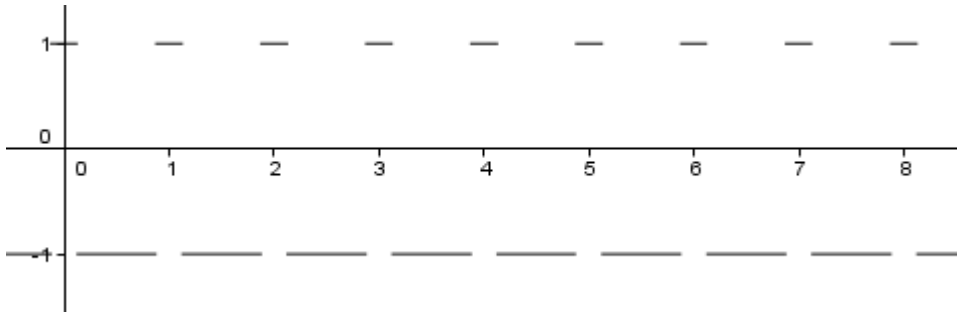
f1(x) = cos(2*pi*x)



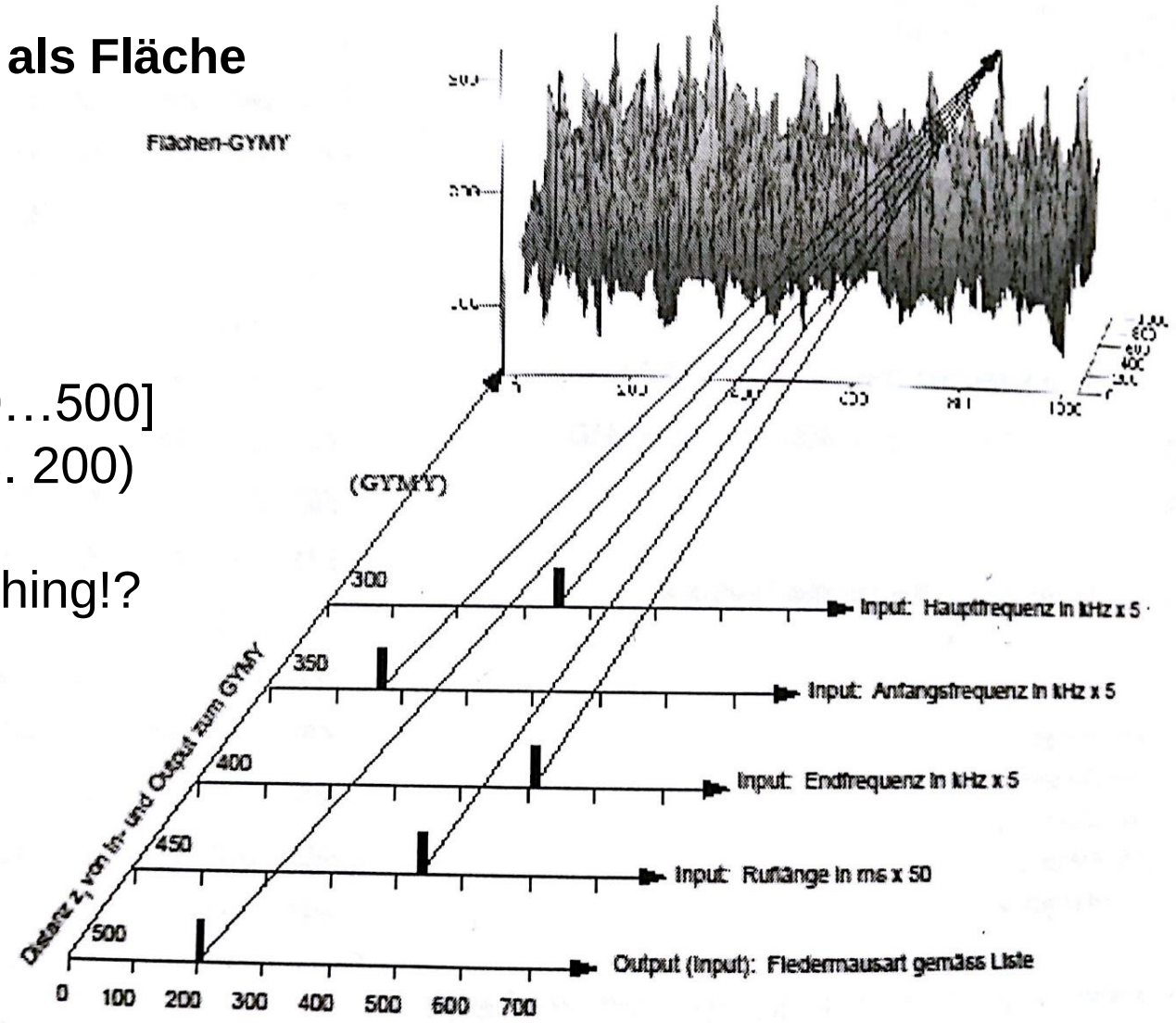
f2(x) = if(cos(2*pi*x)<0.95) then -0.25 else 1



Neuronal inspiriert:
f3(x) = if(cos(2*pi*x)<0.707) then -1 else 1



Gymy – Input als Fläche



Beispiel:

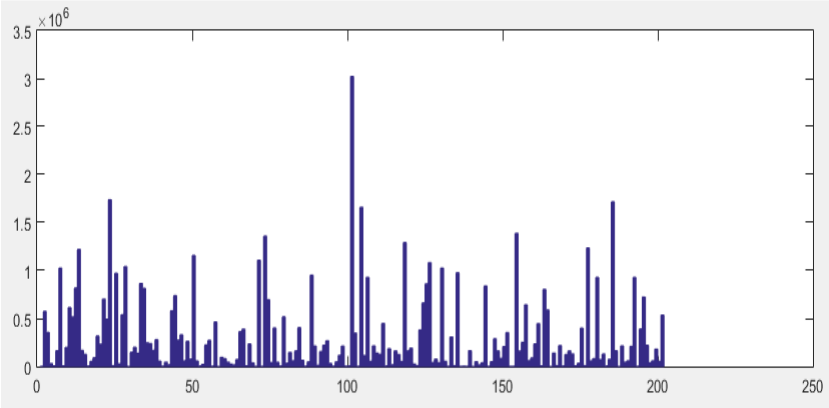
- 4 Features [0…500]
- 1 Klasse (z.B. 200)

=> Pattern Matching!?

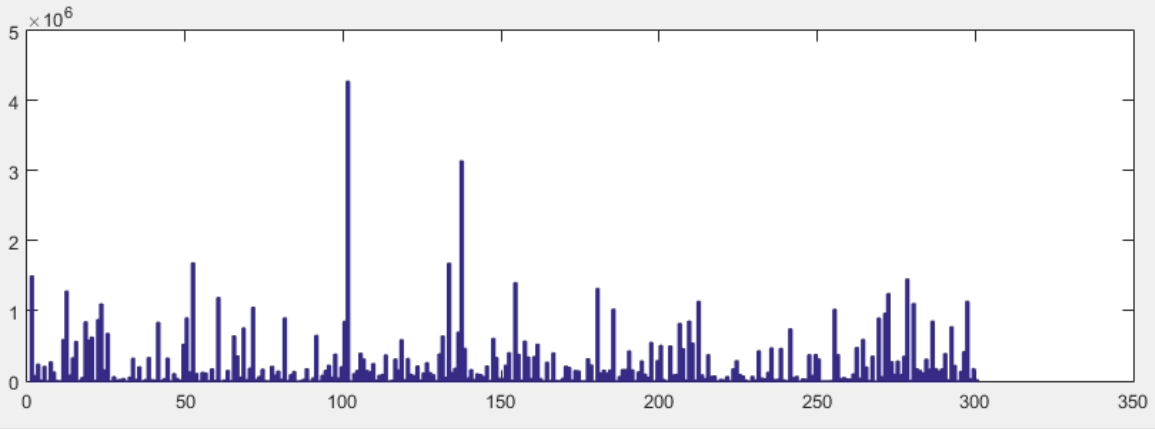
Gymy – Beispiele (2D)

Training:
32 Samples mit je 10 Werten

Gymy:
40’401 Punkte (201*201)
Rek mit 90%



Gymy:
90’000 Punkte (300*300)
Rek mit 50%



Implementation


```
void FlatGymy::gymy_builder_serial(vector<double>& gArr, const int depth,
    const int size,
    vector<double>& inputArr, const int rows, const int elements){
    const int y0 = 500;
    const int q = 1;
    for (int y = 0; y < depth; y++) {
        for (int x = 0; x < size; x++) {
            for (int j = 0; j < rows; j++) {
                double sum = 0;
                for (int i = 0; i < elements; i++) {
                    sum += cos(2 * M_PI / q * sqrt(pow(y0 + y, 2) + pow(x
                    - inputArr[j*elements + i], 2)));
                }
                gArr[y*size + x] += pow(sum, 2);
            }
        }
    }
}
```

```
void FlatGymy::gymy_builder_amp(vector<double>& gArr, const int depth,
  const int size,
    vector<double>& inputArr, const int rows, const int elements){
    const int y0 = 500;
    const int q = 1;

    array_view<double, 2> gA(depth, size, gArr);
    array_view<const double, 2> input(rows, elements, inputArr);


    //for (int y = 0; y < depth; y++) {
        //for (int x = 0; x < size; x++) {
            parallel_for_each(
                gA.extent,
                [=](index<2> idx) restrict(amp)
            {
                double y = idx[0], x = idx[1];
                for (int j = 0; j < rows; j++) {
                    double sum = 0;
                    for (int i = 0; i < elements; i++) {
                        sum += cos(2 * M_PI / q * sqrt(pow(y0 + y, 2) +
                  pow(x - input(j,i), 2)));
                    }
                    gA(idx) += pow(sum, 2);
                }
            });
            gA.synchronize();
        //}
    //}
}
```

Implementation – Qualität einer Rekonstruktion

$$Qualität\ q = 1 - \frac{\max\{x \in Gymy | x \neq \max(Gymy)\}}{\max(Gymy)}$$

1 => Gute Qualität, eindeutiges Resultat

0 => Schlechte Qualität, nicht eindeutiges Resultat

Falsche Rekonstruktionen haben in der Regel auch eine schlechte Qualität.

Resultate - Fledermausbeispiel

- 4 Fledermaustypen (100, 200, 300, 400)
- Je 8 Training-Samples (Total 32)
- 4 Test-Samples
- Jedes Sample mit 4 Features
  - Hauptfrequenz
  - Endfrequenz
  - Anfangsfrequenz
  - Ruflänge
- Gymy: 201*201 (40’401 Punkte)
- Herr Gysin’s Mathwork Variante: ~55min für 1 Sample
- Meine c++ amp Variante: ~1min für alle 32 Samples bzw. ~4s für 1 Sample
  - Average Quality: 0.849489
  - Fehler in den Trainingsdaten: 1
  - Fehler in den Testdaten: 0

```
>{ 340, 204, 167, 264, 100},
>{ 212, 180, 164, 371, 100},
>{ 433, 214, 185, 226, 100},
>{ 431, 214, 183, 235, 100},
>{ 340, 189, 157, 286, 100},
>{ 354, 198, 154, 294, 100},
>{ 369, 192, 155, 298, 100},
>{ 357, 180, 150, 307, 100},

>{ 248, 198, 174, 386, 200},
>{ 297, 198, 174, 338, 200},
>{ 262, 198, 176, 322, 200},
>{ 245, 192, 171, 354, 200},
>{ 242, 192, 176, 354, 200},
>{ 257, 201, 174, 327, 200},
>{ 254, 192, 169, 399, 200},
>{ 404, 229, 173, 369, 200},

>{ 494, 241, 217, 329, 300},
>{ 393, 241, 219, 247, 300},
>{ 461, 244, 216, 344, 300},
>{ 509, 232, 216, 271, 300},
>{ 392, 226, 212, 282, 300},
>{ 366, 226, 211, 288, 300},
>{ 469, 232, 204, 275, 300}
```

```
//Test
vector<double>{ 343, 180, 154, 326, 100},
vector<double>{ 390, 238, 171, 327, 200},
vector<double>{ 428, 235, 216, 310, 300},
vector<double>{ 409, 290, 267, 346, 400}
```

Resultate - Fledermausbeispiel

size	depth	type	classes	samples	elementsPerSample	ignoredElements	averageQuali	RekErrors	dauer	modi
201	201	normal	4	32	4	0	0.849489	1	64.84	alle
350	350	normal	4	32	4	0	0.916217	0	318.639	alle
350	350	normal	4	32	4	1	0.887512	0	279.88	alle
350	350	normal	4	32	4	2	0.888706	2	102.002	alle
500	350	normal	4	32	4	2	0.904634	2	264.227	alle
350	500	normal	4	32	4	2	0.916999	2	217.68	alle
500	500	normal	4	32	4	2	0.926925	2	267.004	alle
201	201	normal	4	32	4	0	0.565772	0	9.302	test4
250	250	normal	4	32	4	0	0.460571	1	13.09	test4
350	350	normal	4	32	4	0	0.560468	0	25.893	test4
500	500	normal	4	32	4	0	0.751319	0	52.381	test4
350	350	neuron	4	32	4	0	0.179468	2	25.943	test4
500	500	neuron	4	32	4	0	0.303133	0	53.361	test4

Resultate - Iris

- 3 Klassen
- 4 Features
- Je 45 Training-Samples (Total 135)
- 15 Test-Samples

size	depth	type	classes	samples	elementsPerSample	ignoredElements	averageQuali	RekErrors	dauer	modi
201	201	normal	3	135	4	0	0.655604	21	279.31	alle
350	350	normal	3	135	4	0	0.711765	20	1356.52	alle
500	500	normal	3	135	4	0	0.691586	18	3798.05	alle
350	350	normal	3	135	4	0	0.61091	5	197.329	test15
500	500	normal	3	135	4	0	0.581895	5	428.653	test15
250	250	neuron	3	135	4	0	0.339907	5	51.373	test15

Resultate - Zufallszahlen

size	depth	type	classes	samples	elementsPerSample	ignoredElements	averageQuali	RekErrors	dauer	modi
250	250	normal	10	30	4	0	0.840438	0	95.984	alle
250	250	normal	10	100	4	0	0.5411393	5	385.907	alle
250	250	normal	10	30	20	0	0.462259	2	916.735	alle
250	250	normal	10	10	20	0	0.836411	0	276.198	alle
250	250	normal	10	10	20	5	0.79183	0	205.57	alle
250	250	normal	10	10	20	10	0.638479	0	132.142	alle
250	250	normal	10	10	20	15	0.328712	4	51.532	alle
250	250	normal	10	30	50	0	0.0263044	1	267.127	last5
250	250	normal	10	30	50	0	0.157827	1	288.055	last5
250	250	normal	10	30	50	10	0.17993	3	297.715	last5
350	350	normal	10	10	20	10	0.811648	0	160.149	last5
400	250	normal	10	10	20	10	0.786932	0	122.566	last5
400	400	normal	10	10	20	0	0.91092	0	435.562	last5
250	250	neuron	10	30	4	0	0.479908	0	96.034	alle
350	350	neuron	10	10	20	10	0.494278	0	79.817	last5
250	250	neuron	10	10	20	15	0.187705	1	50.75	alle
250	250	neuron	10	30	30	0	0.705871	0	431.284	alle
250	250	normal	10	30	50	0	0.212716	21	1578.72	ale

Fazit

- Das Gymy funktioniert grundsätzlich in seiner Funktion als Assoziativspeicher

- Die Rekonstruktion könnte anstatt der Euklidischen Distanzen durch Gewichte ersetzt werden -> Performanzgewinn.

- Für ein Pattern-Matching ähnlich wie bei einfachen Neuronalen Netzwerken, scheint das Gymy noch nicht bereit zu sein.
  - Es werden für jedes Feature die gleichen fix definierten Gewichte verwendet.
  - Einflüsse der Interferenzen auf die Rekonstruktion nicht intuitiv.

Danke für eure Aufmerksamkeit.