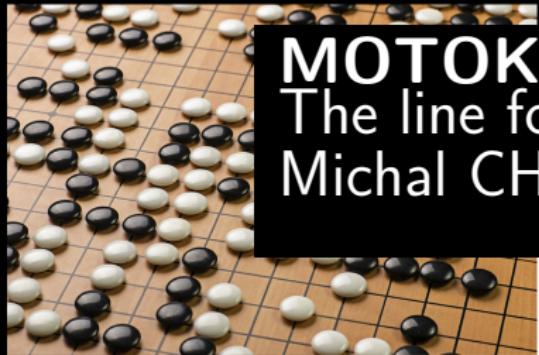


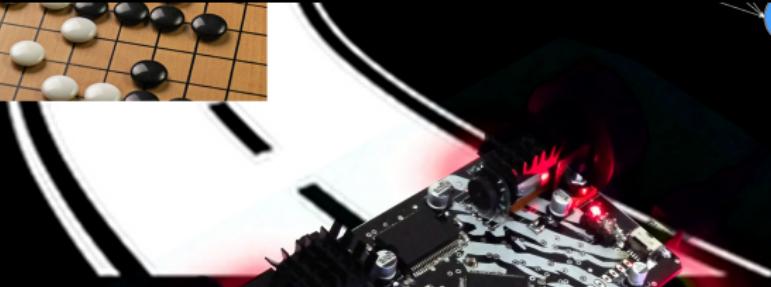
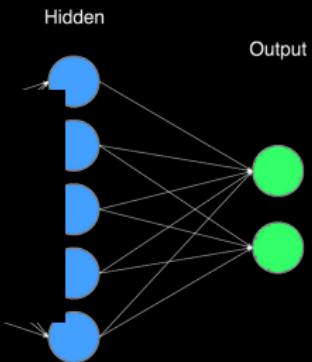
$$Q(s_t, a_t) \leftarrow Q(s_t, a_t) + \alpha [r_{t+1} + \lambda \max_a Q(s_{t+1}, a) - Q(s_t, a_t)]$$

(The New Action Value = The Old Value) + The Learning Rate \times (The New Information — the Old Information)

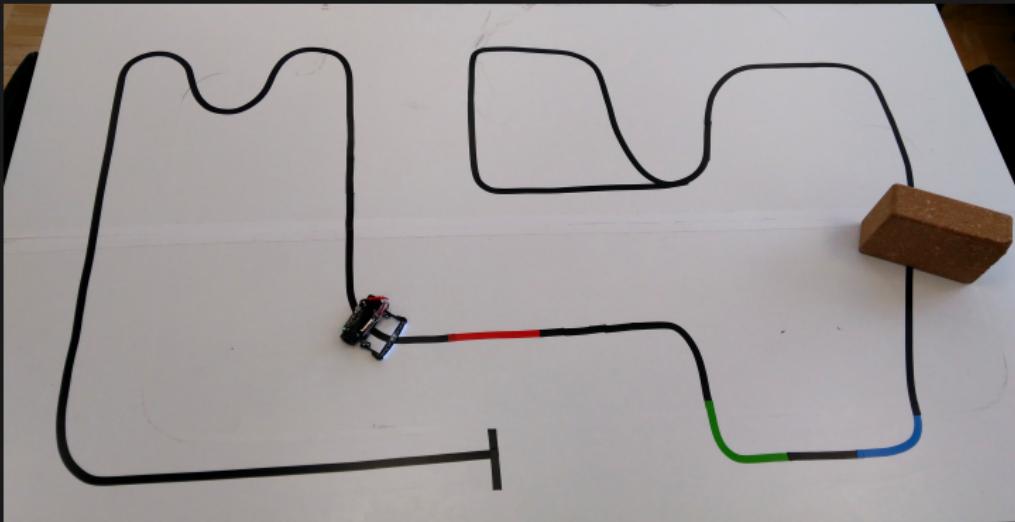


MOTOKO UPRISING

The line following robot Michal CHOVANEC, PhD



Line follower competition



- SR - Istrombot
- CR - Roboticky den
- AU - Robot Challenge
- PL - Zawody robotow

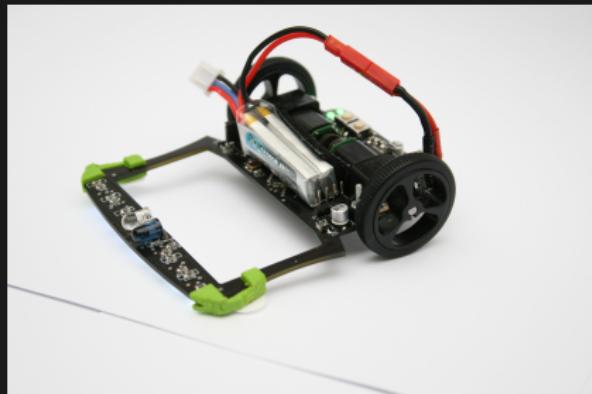
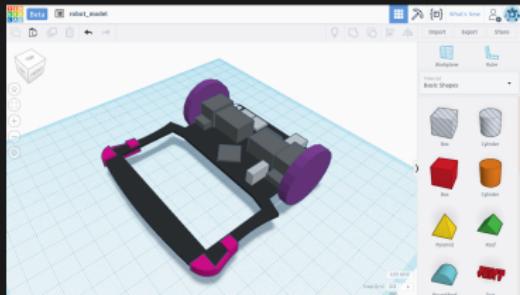
What does it take

- Hardware

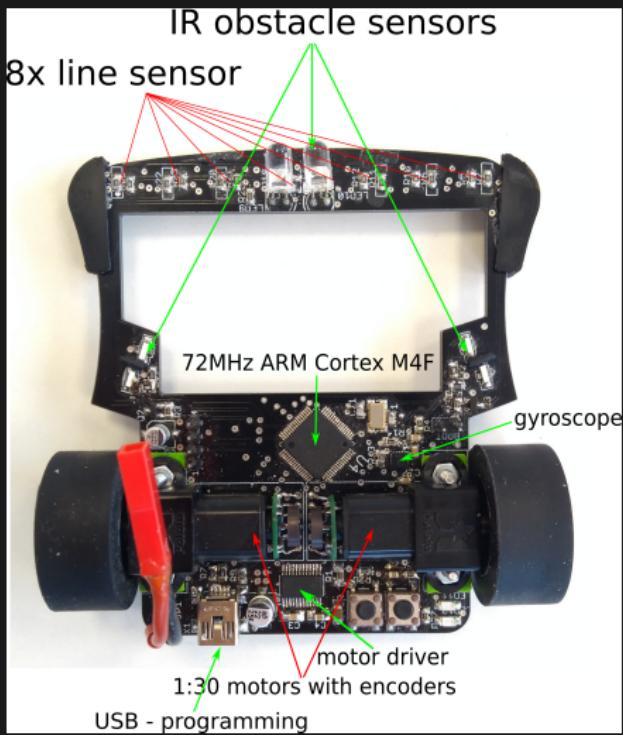
- strong light motors
- high adhesion tyres
- light accumulator
- fast CPU
- dozen of sensors

- Software

- hard real time OS
- tunned PIDs
- predictive controll
- mapping



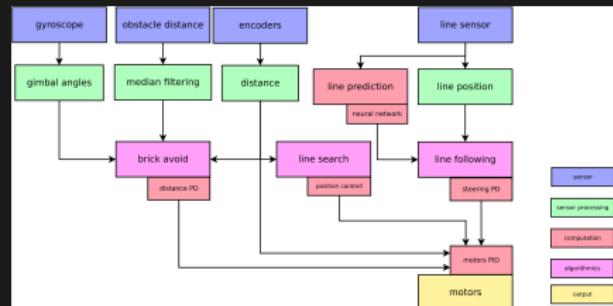
Motoko uprising - hardware



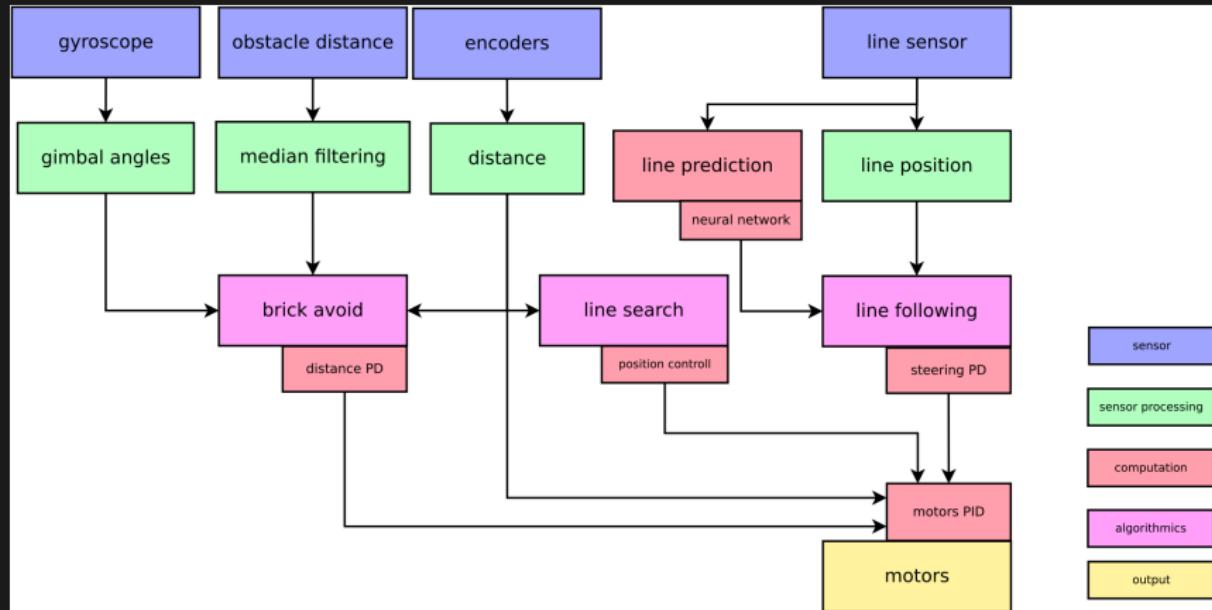
- **mcu** : STM32F303, 72MHz ARM Cortex M4F
- **motor driver** : TI DRV8834
- **motors** : 1:30 HP Pololu, with magnetic encoder
- **tyres** : Pololu 28mm diameter
- **line sensor** : 8x 540nm phototransistor + white LED
- **obstacle sensor** : SMD IR phototransistor + IR LED
- **imu** : LSM6DS0, gyroscope + accelerometer

Software

- **quadratic interpolation** : high precision line position computing
- **steering PID** : PD controller for steering
- **motor PID** : two PIDs for motors speed controll
- **curve shape prediction**
 - **fast** run on straight line, **brake** on curve
 - **deep neural network**
- written in **C++**
- **network training** on GPU - own framework for CNN

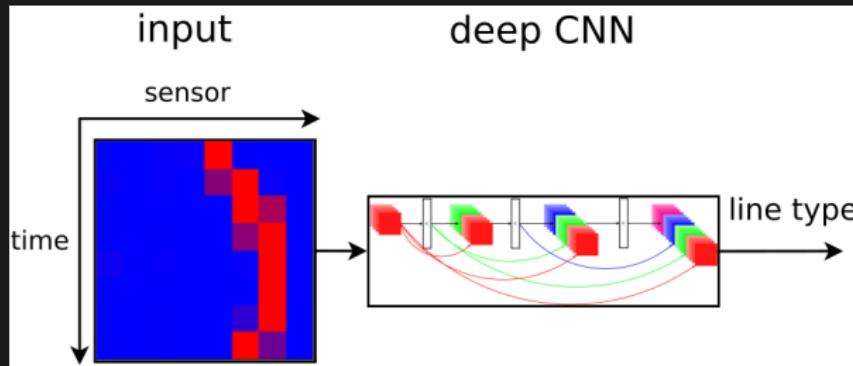


Software

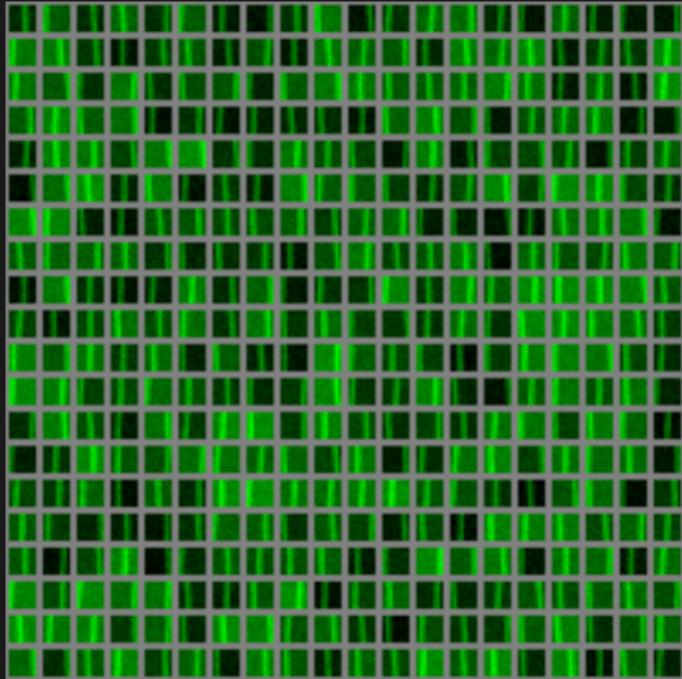


Line shape prediction

- **fast** run on straight line, **brake** on curve
- **neural network** for line type classification
 - DenseNet - densely connected convolutional neural network
- **input** 8x8 matrix raw data from line sensors
 - 8 past line positions from 8 sensors
- **output** 5 curves types



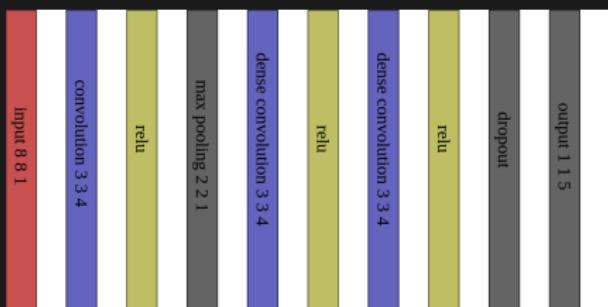
Line dataset



- 20000 for training
- 2500 for testing
- 8x8 inputs
- 5 outputs (5 curves types)
 - two left
 - one straight
 - two right
- augmentation - luma noise, white noise

Neural networks architecture

layer	net 0	net 1	net 2	net 3
0	conv 3x3x4	conv 3x3x6	conv 3x3x4	conv 3x3x6
1	max pooling 2x2	max pooling 2x2	max pooling 2x2	max pooling 2x2
2	dense conv 3x3x4	dense conv 3x3x6	dense conv 3x3x4	dense conv 3x3x6
3	fc 5	fc 5	dense conv 3x3x4	dense conv 3x3x6
4			fc 5	fc 5



Networks results

layer	net 0	net 1	net 2	net 3
success [%]	94.04	93.92	94.96	96.32
FLOPS	7754	13354	13578	25546
success / FLOPS	0.01213	0.00703	0.00699	0.00377

net 2 confusion matrix

class	0	1	2	3	4
0	520	8	0	0	0
1	12	453	15	0	0
2	0	12	483	10	0
3	0	0	15	461	53
4	0	0	0	1	457
class success [%]	97.744	95.772	94.152	97.669	89.608
total success [%]	94.96				

Fitting network into embedded

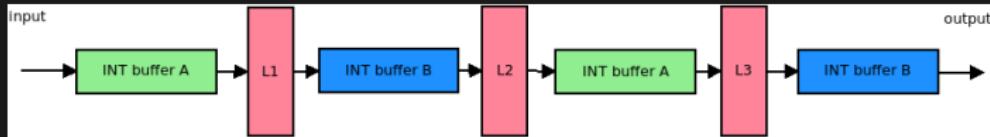
convert float weights to int8_t

$$scale = \max(|\vec{w}|_1)$$

$$\vec{w}' = \vec{w} \frac{127}{scale}$$

use double buffer memory trick

- `unsigned buffer_size = max_i(layers[i].input_size());`
- `buffer_a = new int8_t(buffer_size);`
- `buffer_b = new int8_t(buffer_size);`



Q&A



michal chovanec (michal.nand@gmail.com)
www.youtube.com/channel/UCzVvP2ou8v3afNiVrPAHQGg
github <https://github.com/michalnand>

Thanks for watching



- Github
 - author <https://github.com/michalnand>
 - robot https://github.com/michalnand/motoko_uprising
- Music provided by No Copyright Music:
 - Music used: Royal Rumble by Jay Man - OurMusicBox
 - <https://www.youtube.com/c/royaltyfreezone>
 - Music used: Rise Again by Alexander Nakarada @ SerpentSound Studios
 - https://youtu.be/FC_ER8wr7Fs
 - Licensed under Creative Commons Attribution 4.0