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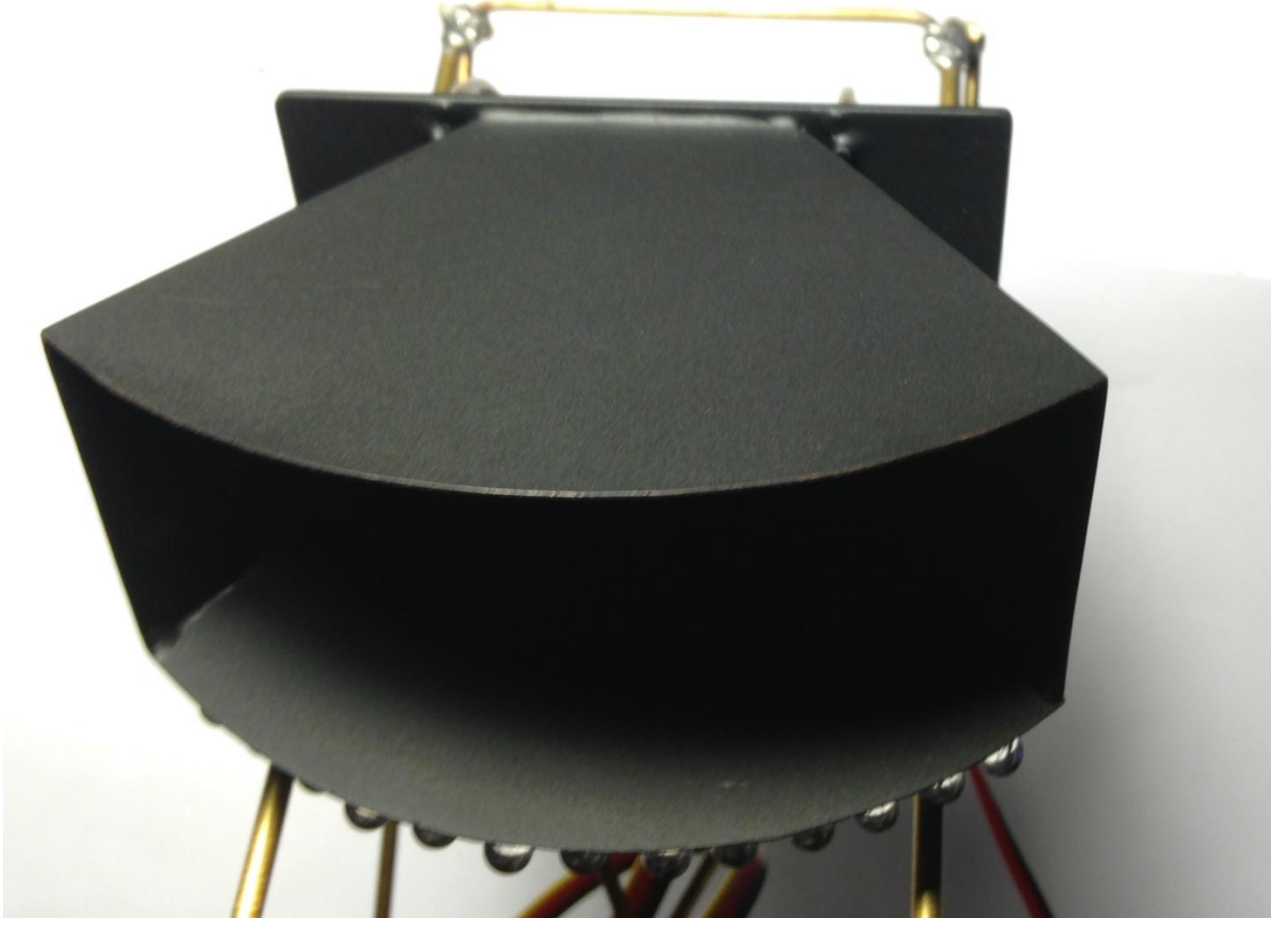
Obsah

Mechanical design of vehicle model

We use original race car model, for camera mount we use spacers and wires for camera stability. While testing camera we found out that camera is very sensitive on light and when lighting exceeds critical state camera is in saturation and data from camera are useless and we read out from datasheet that camera is very sensitive on red light 750 nm wavelength . We solve this problem with small shield for camera lens and appropriate exposition time and with red led lighting on the camera shield.



Img 1: Camera shield

Control circuit design

Control circuit is based on:

FRDM-KL25Z development board which is based on MKL25Z128VLK4 MCU 48 MHz, 128 KB flash, 16 KB SRAM

The Freescale cup shield for FRDM-KL25Z which include h-bridge motor drivers, potentiometers buttons and switches

Line scan camera, NiMH battery pack, steering servo, two dc motors, and lightning made from red leds.

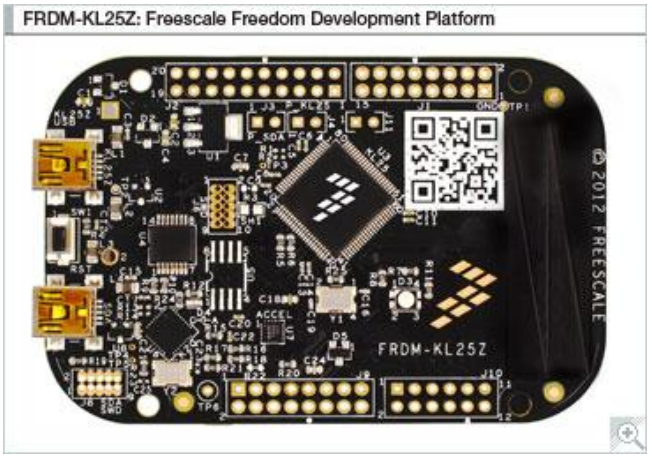
Electronics design

Electronics used on racing car is without any changes.
We use:

7,2V 2400mAh NiMH battery

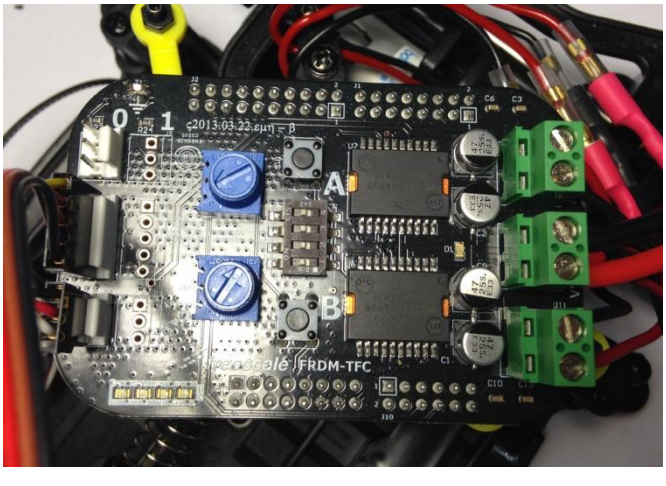
Img 2: battery pack

FRDM-KL25Z development platform



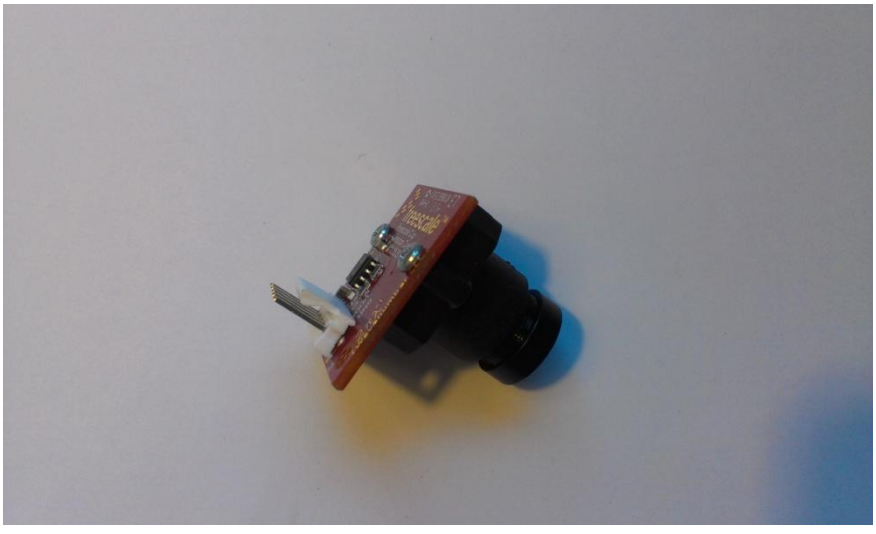
Img 3: FRDM-KL25Z

Freescale Cup Shield for the Freedom KL25Z



Img 4: TFC shield

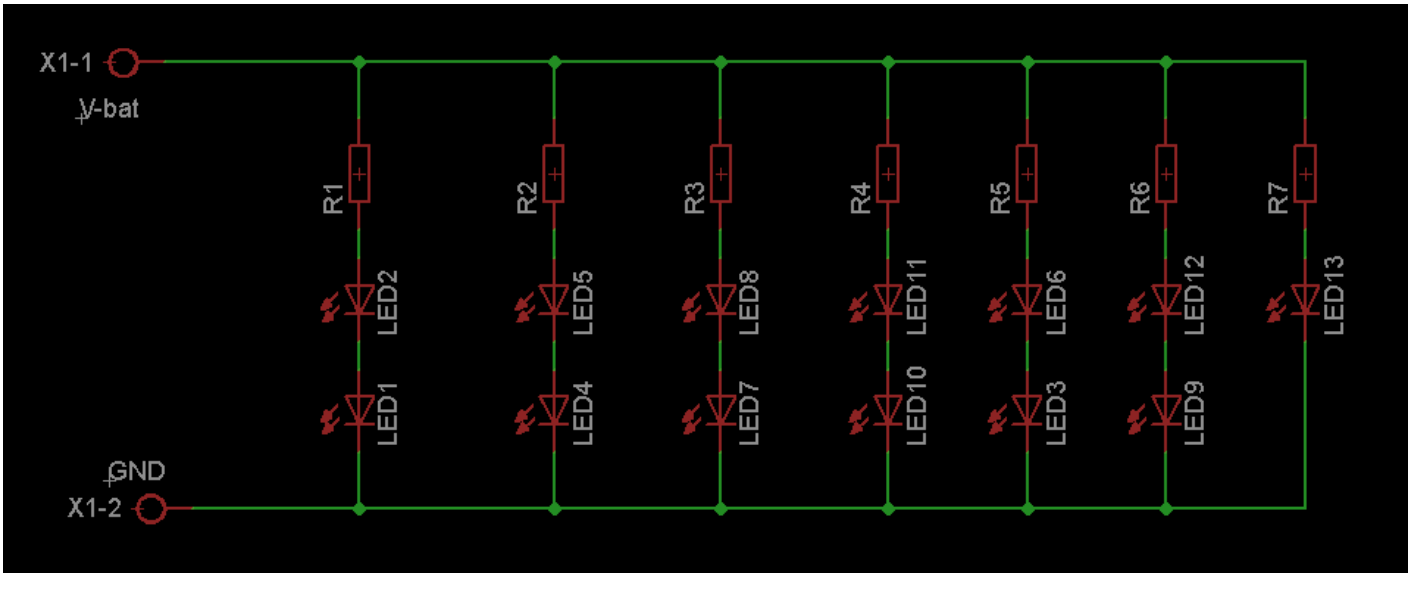
Line scan camera



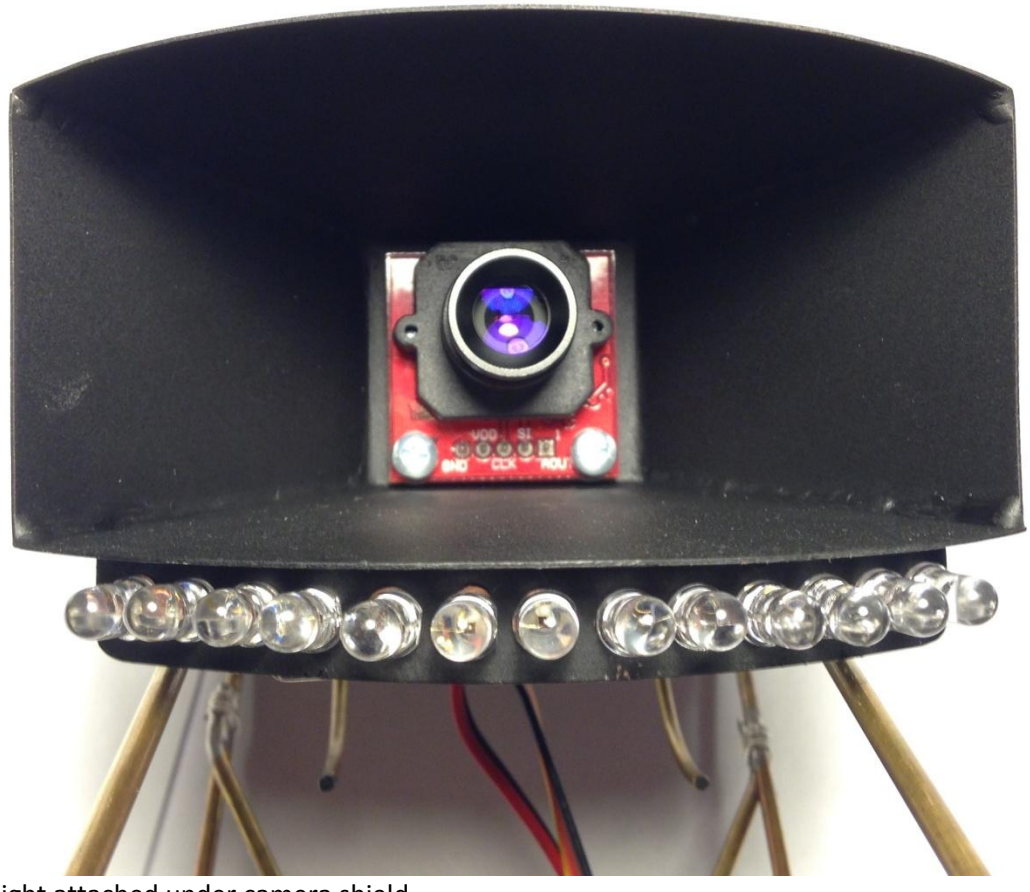
Img 5: Line scan camera

Red led lightning

To improve camera vision we used red led lightning. W used series-parallel connection of LEDs which has each 2,4 voltage drop. As ballast resistor R1-R6 we count 120R and R7=220R.



Img 6: Schematic of led connection



Img 7: red led light attached under camera shield

Control software design

Firstly we make initialization of I/O pins or their alternative function and prepare all for main infinitive loop. In main loop we only call our predefined functions. Firstly to scan data from camera and store them to array of 128 elements, then convolution function to clear data from camera and determine line, in the end is function to set servo pulse width depending on which element was determined as center of black line. to detect end line is used simple arithmetic mean of convoluted data where is condition which stops motors.

Scan line function

In this function we sample data by ADC which is connected to camera. We can set exposition time by parameter in function which set delay between pixel sampling time.

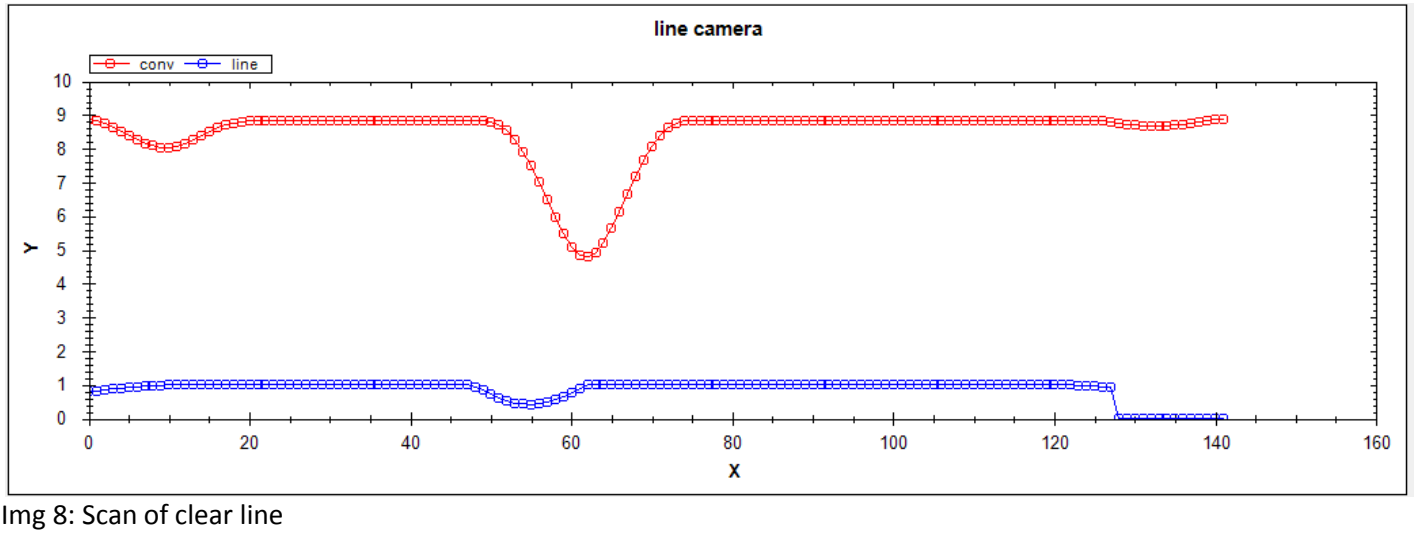
Line camera (Convolution)

We found out that signal from camera is not as clear to be used for determining where is the center of line. Firstly we add correction data to remove distortion from camera lens, we scan white background and then add 10 elements to original camera signal. To make this corrected signal clear is used convolution with sine wave core which perfectly clear camera signal and highlight scanned line. From this array is determined smallest element, which is in the right light conditions black line. Camera data must be expanded by 14 elements with number 1 on the each side of array so that convolution calculation make sense.

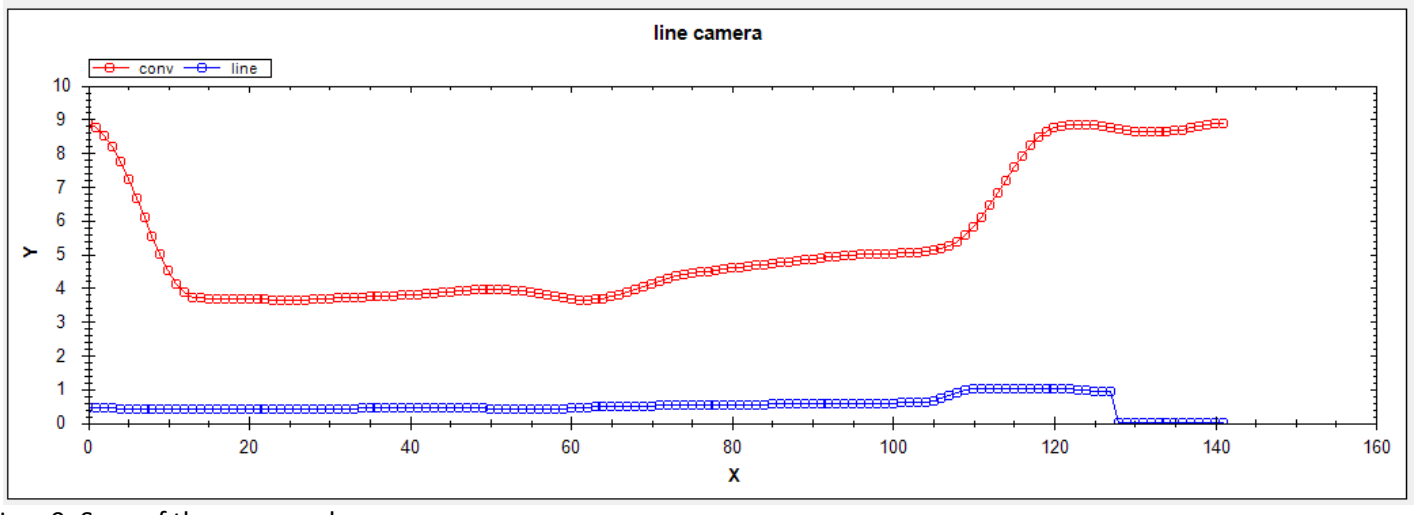
Sine wave convolution core include 15 elements:

0,
0.222,
0.433,
0.623,
0.781,
0.900,
0.974,
1,
0.974,
0.900,
0.781,
0.623,
0.433,
0.222,
0

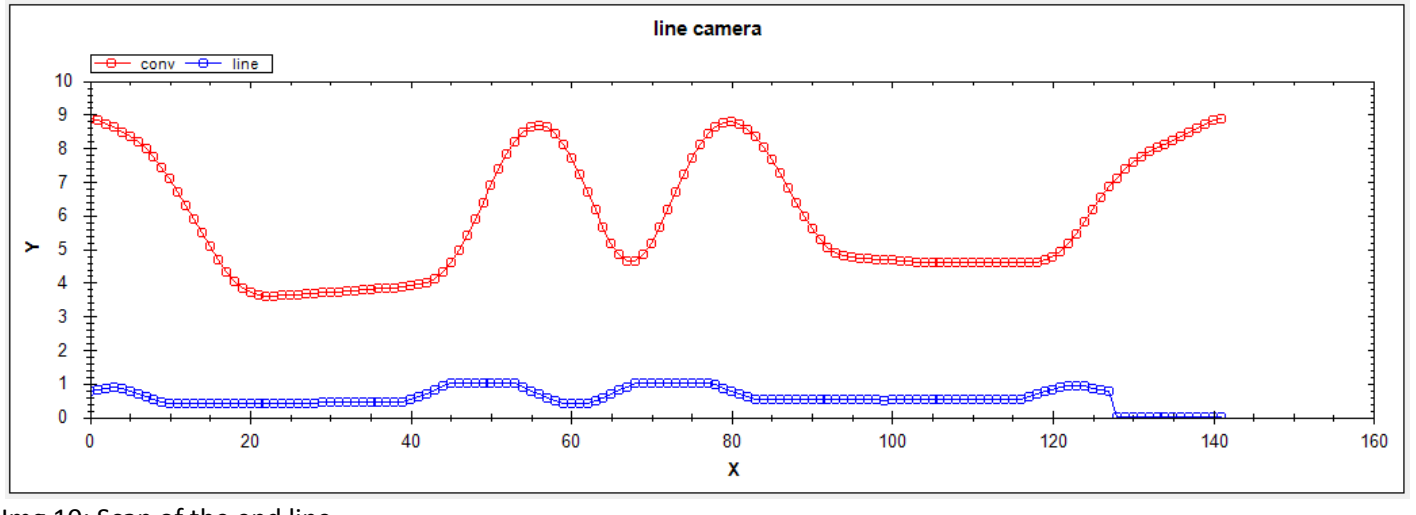
To see what camera vision look like and how convolution is made with data we made C# application to receive camera data through open SDA serial port. We use this application to focus camera and debug camera data. From printscreens bellow you can see how convolution make center of line clear.
Blue line are clear data from camera, red line are data after convolution



Img 8: Scan of clear line



Img 9: Scan of the crossroad



Img 10: Scan of the end line

Total weight and dimensions of the reengineered vehicle

length: 275mm

width: 163mm

height: 235mm

total weight with mounted battery : 1097g

total weight without battery: 783g

Power consumption

We measured power consumption in different conditions with no load on wheels and with fully charged battery 7,4V.

Motor pwm period is set on 100us

1. min speed (8% DT) - power consumption -0,479 A

1. max speed (100%DT) - power consumption -2,132A

Count and type of sensors used

Our car is using only one sensor for detection track line.

1. **Line scan camera** 128x1 px line camera based on TSL1401 linear array sensor.

Conclusion

while we worked on this car we learnt a lot of new thinks from programming, signal processing, driving complex system and more. We are better in team working and solving small problems to solve big one. We learnt a lot about FRDM-KL25Z development board its processor and all components, then we worked with tfc shield where is motor drivers with whom we worked for the first time in this application. We wrote all code in Mbed but we find out this internet compiler little buggy, because sometimes the same compiled code runs and sometimes not, but we finished successfully this project.