Autonomous vehicle on RC model car chassis for NXP CUP

Line-following robot with dual-MCU architecture and linear CCD camera

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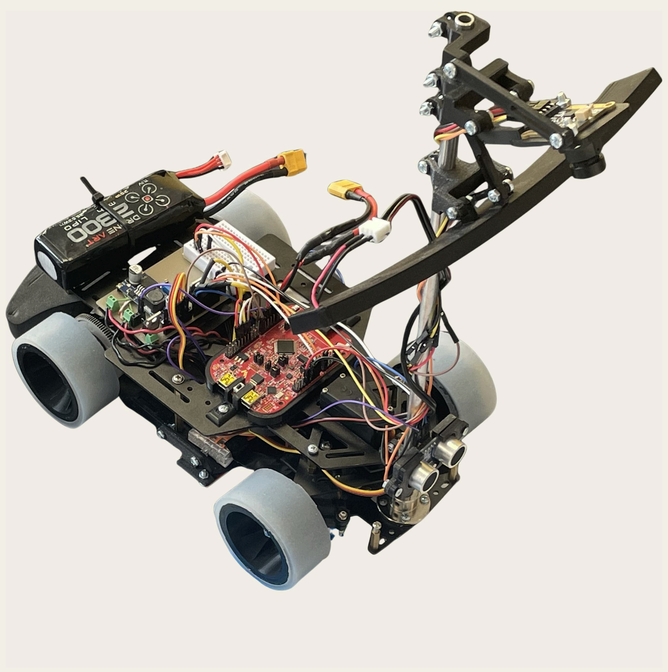
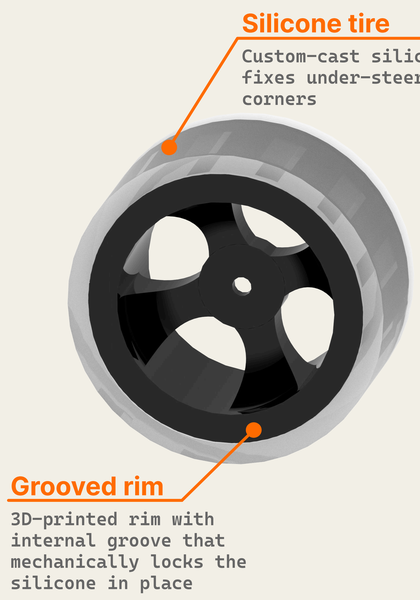
VIDEO

COMPETITION RESULT:
3rd Place NXP Cup





Parameters

125 Hz – CAMERA FRAME RATE

2.7 m/s – MAX SPEED

COMPONENTS:

BOARD	2x FRDM-KL27Z
MCU	MKL27Z64VLH4
DISTANCE	HC-SR04 ultrasonic
CAMERA	TSL1401
SERVO	MG966R, 7 V
MOTORS	BLDC, 930 kV
FINISH LINE	6x TCRT5000 IR sensors
BATTERY	LiPo 3S, 2300 mAh, 45C
LIGHT	LED strip, 19.6 W/m

FIG. 2 SYSTEM OVERVIEW

Distributed Dual-MCU Architecture

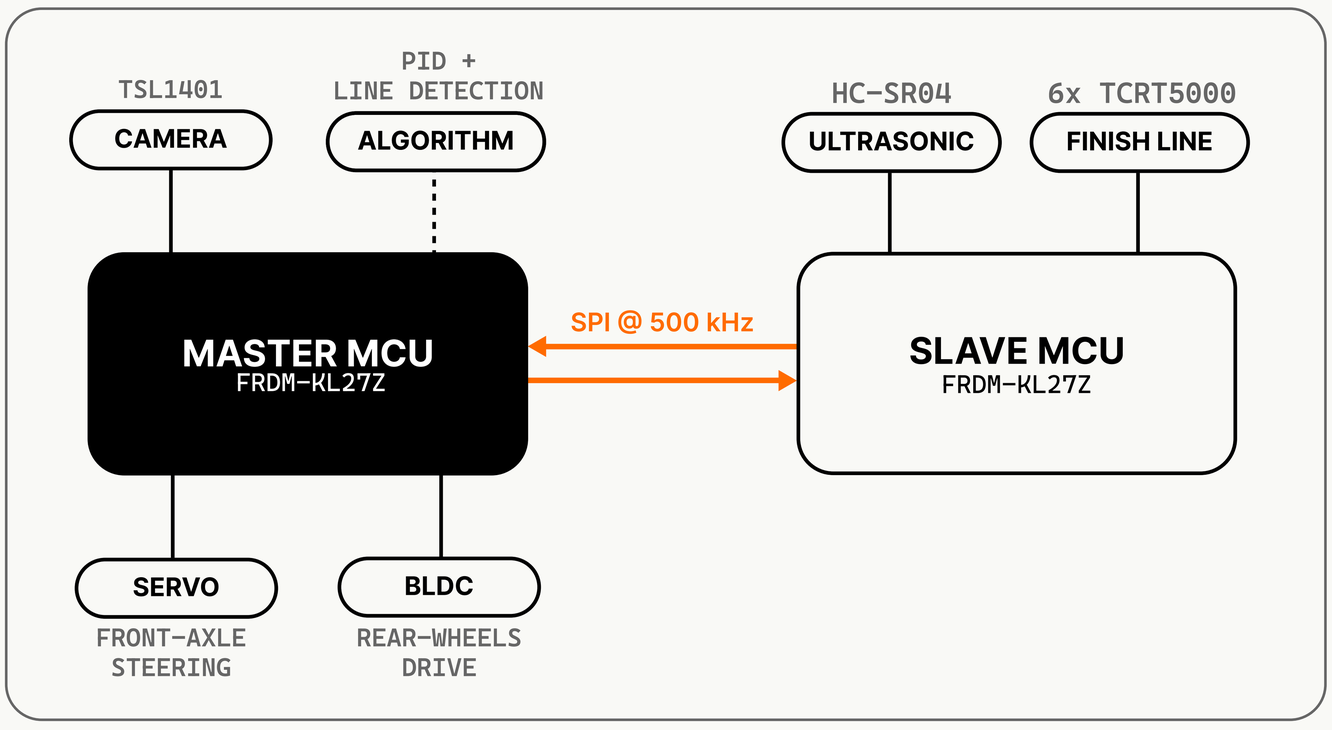


FIG. 4 SIGNAL ANALYSIS

Line Detection Signal Analysis

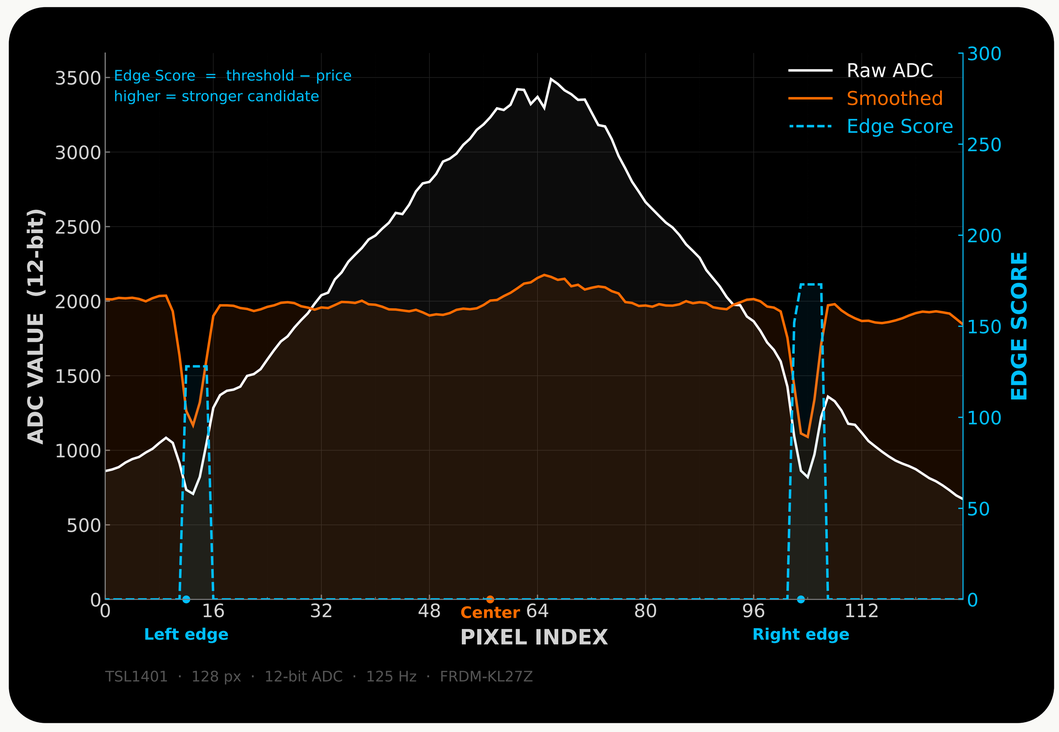


FIG. 3 PROCESSING PIPELINE

Line-detection pipeline

01 Raw data
- 128 px / frame
- 12-bit samples
- 125 Hz capture
- **Async data** collection using ADC and DMA

02 Compensation + Median
- flattens pixel sensitivity using a stored calibration profile
- applies calibration profile
- 8px median filter
- removes single-pixel spikes

03 Adaptive Threshold
- measures average (**avg**) brightness
- auto-adapts each frame
- **threshold = avg - C**
  C - fixed constant
- marks pixels darker than threshold

04 Where to Look
- search around last detected lines
- **tracks the line** frame to frame
- wide fallback zones if lost
- if one side lost, searches only from the side it disappeared at

05 Cost-Scored Candidates
- scores every dark candidate
  `price = I(i) + λ · |i − î|`
- `I(i)` – smoothed intensity
  `î` - previous-frame position
  `λ` - 0.2 distance penalty
- checks minimum track width

06 Line Data
- left edge position
- right edge position
- **center = (L + R) / 2**
- or estimated from one edge if the other is lost
- lost-line flag for safety logic

FIG. 5 CONTROL ALGORITHM

Steering & Stop Logic

07 Dual-PID & speed
- **Normal PID:** stable, used in curves
- switches to Fast PID when line is centered & both edges visible
- **Fast PID:** softer gains, smoother steering at high speed
- falls back to Normal on first sign of trouble/curve

08 Stop logic
- finish-line sensors trigger the arming sequence
- ultrasonic then monitors for the approaching end wall
- stop is confirmed only after **several decreasing distance** readings