



# Vhodno-izhodne naprave (VIN)

Predavanja

## 12.b VIN projekt in SensorTile.box

Robert Rozman

[rozman@fri.uni-lj.si](mailto:rozman@fri.uni-lj.si)

# 12.b VIN projekt in SensorTile.box

## ■ Praktična naloga - VIN Projekt

- Razvojne plošče
- Viri (gradiva, posnetki, primeri, ...)
- Osnovna projekta v CubeIDE:
  - CubeMX (HAL knjižnica, BSP) – STM32H7, STM32F4
    - CubeMX – osnovni projekt (GPIO – tipka, LED diode, USART)
    - BSP – osnovni projekt (Touch, LCD)

## ■ SensorTile.box (kompaktna razvojna platforma)

- Edge Computing platforma

## ■ STM AI ekosistem in Orange Data Mining

# VIN Projekt – Navodila

Preberite podana navodila (OneNote zvezek, LAB vaje s temo VIN projekta) in vsebino oblikujte v skladu s priporočili.

**Poročilo oblikujte v PDF obliki.** Dodajte tudi **infografiko** (grafični povzetek vašega projekta) in **video posnetek**. Vse datoteke (skupaj s poročilom) dajte v zip arhiv in oddajte (video lahko tudi kje objavite ali kako drugače delite z nami, da ga objavimo). Projekt vsaj v obliki tekstovnega povzetka in **infografike objavite tudi v OneNote zvezku VIN - sekcija VIN projekti Teme.**

Projekt **priporočamo, da objavite tudi javno (GitHub, <https://video.arnes.si/>, Youtube, ...)**, skupaj z multimedijskimi datotekami (video posnetek delovanja, poročilo, razlage, skice)...

**Primer zelo dobro narejenega opisa izvedbe projekta**, kjer so podane vse potrebne informacije za razumevanje in samostojno izvedbo projekta: [Snake game on 8x8 LED matrix using the STM32F4 discovery board.](#) | [zrezke's blog](#)

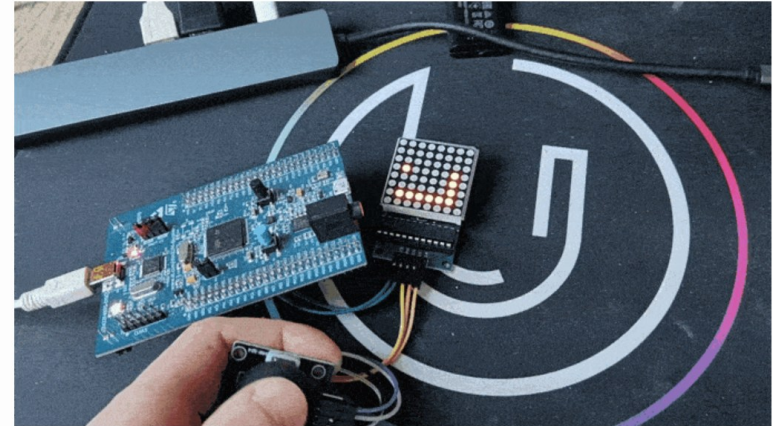
<https://zrezke.github.io/jekyll/update/2022/02/23/8by8-snake.html>

Velikost zip datoteke, ki jo oddate, je omejena na 50MB.

## Snake game on 8x8 LED matrix using the STM32F4 discovery board.

Feb 23, 2022 • Filip Jeretina

In this post we will be implementing a [snake game on bare metal](#). This means we will only use assembly and registers, without any fancy tools such as the CUBEMX :)



### Parts list

- [STM32F407G-DISC1](#) board
- 8x8 LED MATRIX with [MAX7219](#) display driver.
- [Joystick module](#)
- [Wires with female to female dupont connectors](#)

[Snake game on 8x8 LED matrix using the STM32F4 discovery board.](#) | [zrezke's blog](#)

<https://zrezke.github.io/jekyll/update/2022/02/23/8by8-snake.html>

# VIN Projekti – Pregled (OneNote objave tem)

## Preberi.me

sreda, 16. marec 2022 18:09

Tukaj lahko objavljate svoje vsebine, vaš VIN projekt:

- Naredite svojo stran z naslovom VIN projekta
- Naredite lahko podstrani z različnimi vsebinami (viri, gradiva, sheme, ...)
- Imejte kopijo v svojem osebni zvezku - tukaj lahko spreminjamo vsi vsebino.

Predstavitev projekta :

- **Poročilo v PDF obliki (s tekstovnim povzetkom in infografiko na prvi strani)**
  - Objavite tudi na svoji strani v tem zvezku ali spletnem blogu
- **Infografika** - grafični povzetek projekta
- **Kratek video posnetek** - pošljete nam ali objavite sami (link)
- **Priporočilo: GitHub**: opis projekta ([Readme.md](#)) in koda

Vse datoteke oddajte v .zip na e-učilnico (če prevelika, izpustite video).  
Vsaj del vsebine objavite tudi v OneNote zvezku VIN.

Primer odličnega opisa projekta (informativen, izobraževalen, ponovljiv):

[Snake game on 8x8 LED matrix using the STM32F4 discovery board.](#) | zrezke's blog

- 4-wire bipolar stepper motor
- Plant Watering Alert
- Neimenovana stran
- Pametna ura na H7
- Hribovski spremljevalec

### Komentarji, ideje

- Mešalec pijač
- Mešalnik glasnosti
- Sistem DRO za merilne letve
- Parking senzor
- Detekcija predmetov v gibanju in...
- Laser tag
- Infrardeča kamera
- NFC reader na H7
- Povezovanje MicroE Lightange...
- PlantHealth - Nega rastlin
- Rulet na H7
- Space Invaders

### Vizualizacija zvoka

- FireAlarm
- PooF – pametni lonček
- Sistem za spremljanje nivoja v...
- Kalkulator z mehničnimi stikali
- Guess the Colored Cup's Positi...
- Merilec temperature
- GrowBox
- Pametni pastir za govedo
- Neimenovana stran
- Križci in krožci
- Potapljanje ladjic
- T-rex runner

# 12.b VIN projekt in SensorTile.box

## ■ Praktična naloga - VIN Projekt

### □ Razvojne plošče

### □ Viri (gradiva, posnetki, primeri, ...)

### □ Osnovna projekta v CubeIDE:

#### ■ CubeMX (HAL knjižnica, BSP) – STM32H7, STM32F4

##### □ CubeMX – osnovni projekt (GPIO – tipka, LED diode, USART)

##### □ BSP – osnovni projekt (Touch, LCD)

## ■ SensorTile.box (kompaktna razvojna platforma)

### □ Edge Computing platforma

## ■ STM AI ekosistem in Orange Data Mining

# VIN Projekt – Osnovna platforma

## STM32F407 ST Discovery

### STM Discovery F4 (Cortex M4)

- STM32F407VGT6 microcontroller featuring 32-bit Arm® Cortex®-M4 with FPU core, 1-Mbyte Flash memory and 192-Kbyte RAM in an LQFP100 package

### •USB OTG FS

### •ST MEMS 3-axis accelerometer

### •ST-MEMS audio sensor omni-directional digital microphone

### •Audio DAC with integrated class D speaker driver

### •User and reset push-buttons

### •Eight LEDs:

- LD1 (red/green) for USB communication
- LD2 (red) for 3.3 V power on
- Four user LEDs, LD3 (orange), LD4 (green), LD5 (red) and LD6 (blue)

### •Board connectors:

- USB with Micro-AB
- Stereo headphone output jack
- 2.54 mm pitch extension header for all LQFP100 I/Os for quick connection to prototyping board and easy probing

### •External application power supply: 3 V and 5 V

# STM32



## ST Discovery STM32MP157C

### STM Discovery MP1 (2xCortex A7 + 1xCortex M4)

- STM32MP157 Arm®-based **dual Cortex®-A7 32 bits + Cortex®-M4 32 bits MPU** in TFBGA361 package
- 4-Gbit DDR3L, 16 bits, 533 MHz
- 1-Gbps Ethernet (RGMII) compliant with IEEE-802.3ab
- USB OTG HS
- Audio codec
- 4 user LEDs
- 2 user and reset push-buttons, 1 wake-up button
- 5 V / 3 A USB Type-CTM power supply input (not provided)
- Board connectors:
  - Ethernet RJ45 × USB Host Type-A × USB Type-CTM × DRP × MIPI × DSIS × M × HDMI × Stereo headset jack including analog microphone input × microSD × TM card × GPIC expansion connector (Raspberry Pi® shields capability)
- ARDUINO® Uno V3 expansion connectors
- STM32CubeMP1 and full mainline **open-source Linux® STM32** MPU OpenSTLinux Distribution (such as STM32MP1Starter) software and examples
- 4" **TFT 480×800 pixels** with LED backlight, MIPI DSISM interface, and capacitive **touch panel**
- Wi-Fi® 802.11b/g/n**
- Bluetooth® Low Energy 4.1**

STM32MP1

STM32



# VIN Projekt – Osnovna platforma

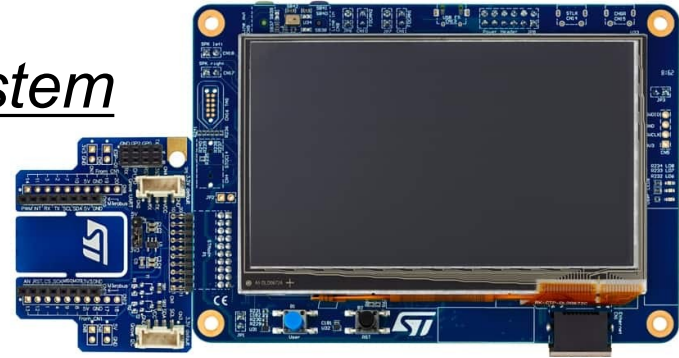
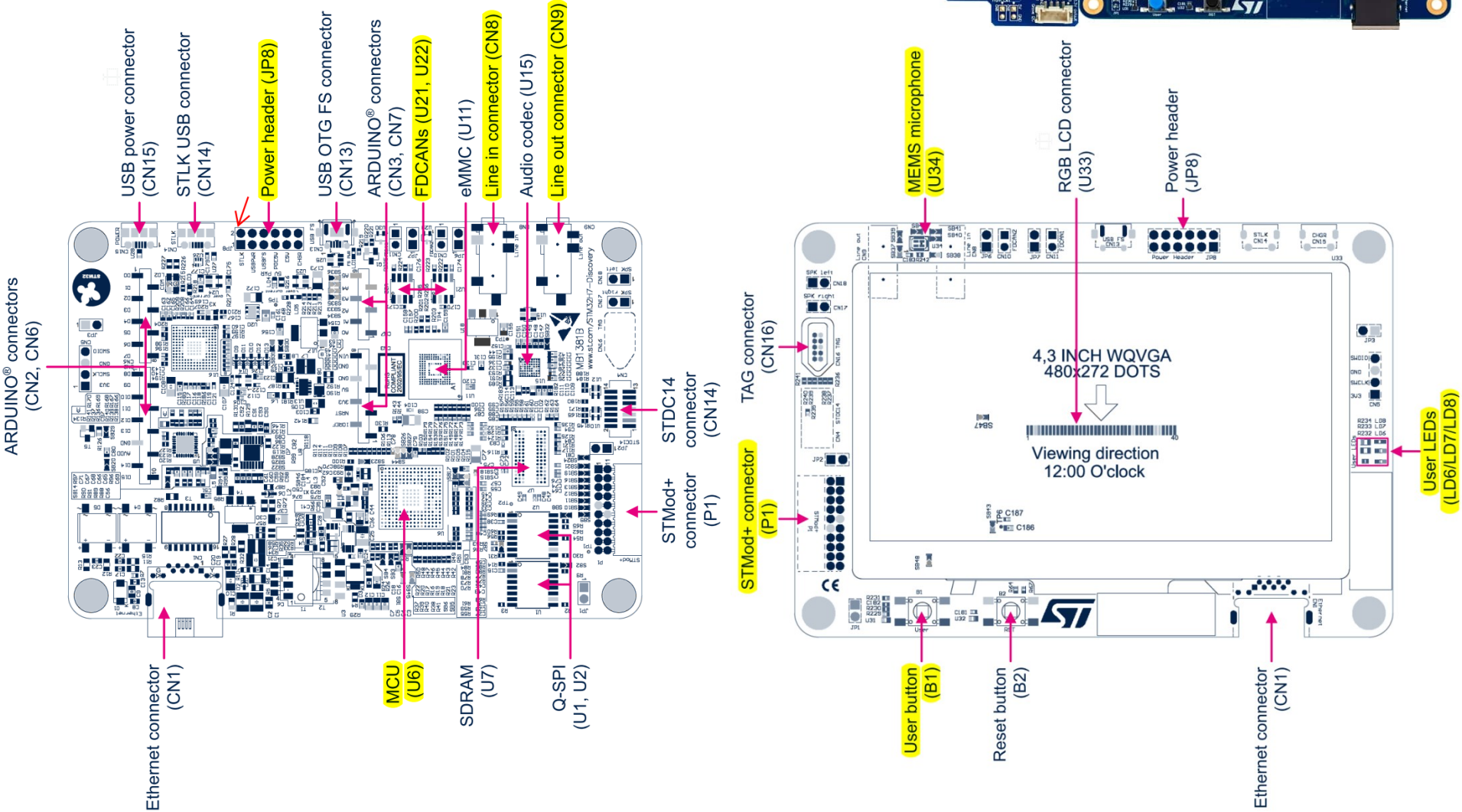
## STM32H750B-DK Discovery razvojni sistem

- Arm® Cortex® core-based microcontroller with **128 Kbytes (STM32H750XBH6) of Flash memory** and **1 Mbyte of RAM**, in TFBGA240+25 package
- 4.3" RGB interface **LCD with touch panel connector**
- **Ethernet** compliant with IEEE-802.3-2002, and **POE**
- USB OTG FS with Micro-AB connector
- SAI audio codec
- One ST-MEMS **digital microphone**
- **2 x 512-Mbit Quad-SPI NOR Flash memory**
- **128-Mbit SDRAM**
- **4-Gbyte on-board eMMC**
- **1 user and reset push-button**
- Fanout daughterboard
- 2 x **FDCANs**
- Board connectors:
  - USB FS Micro-AB connectors
  - ST-LINK Micro-B USB connector
  - USB power Micro-B connector
  - **Ethernet RJ45**
  - **Stereo headset jack including analog microphone input**
  - Audio header for external speakers
  - **Arduino™ Uno V3** expansion connectors
  - **STMod+**



<https://www.st.com/en/evaluation-tools/stm32h750b-dk.html>

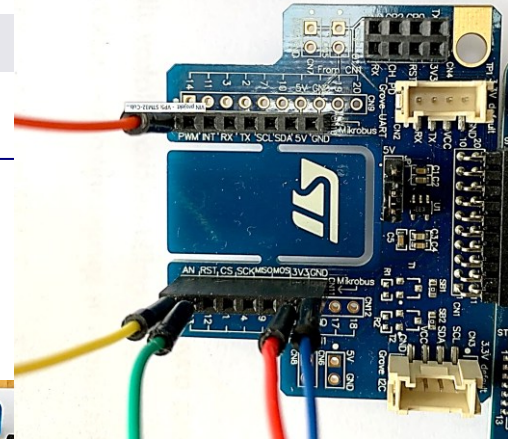
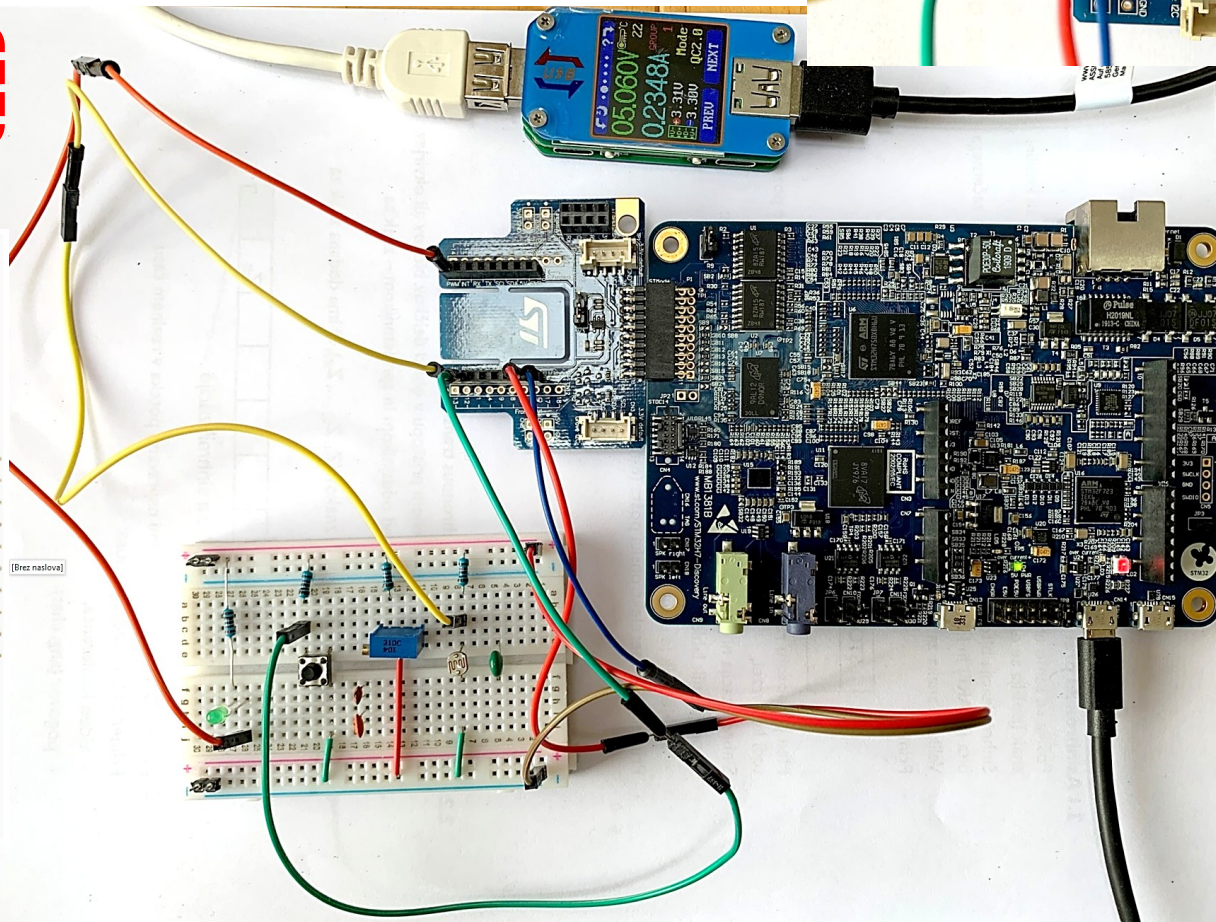
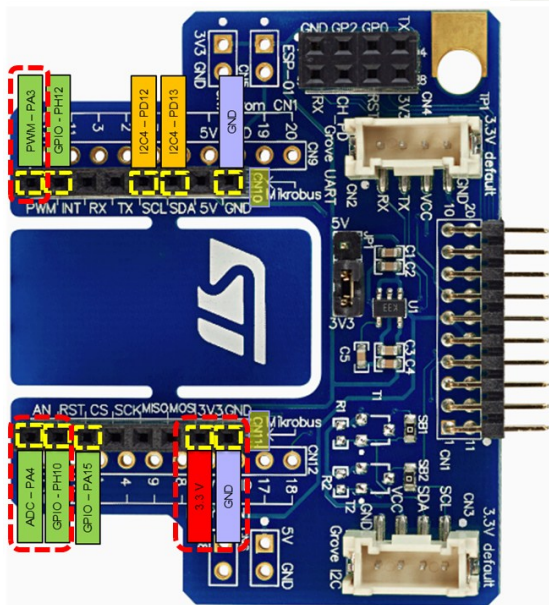
# STM32H750B-DK Discovery razvojni sistem



Priključitev na STM32 : 1x analogni,  
1x digitalni vhod, 1x digitalni izhod

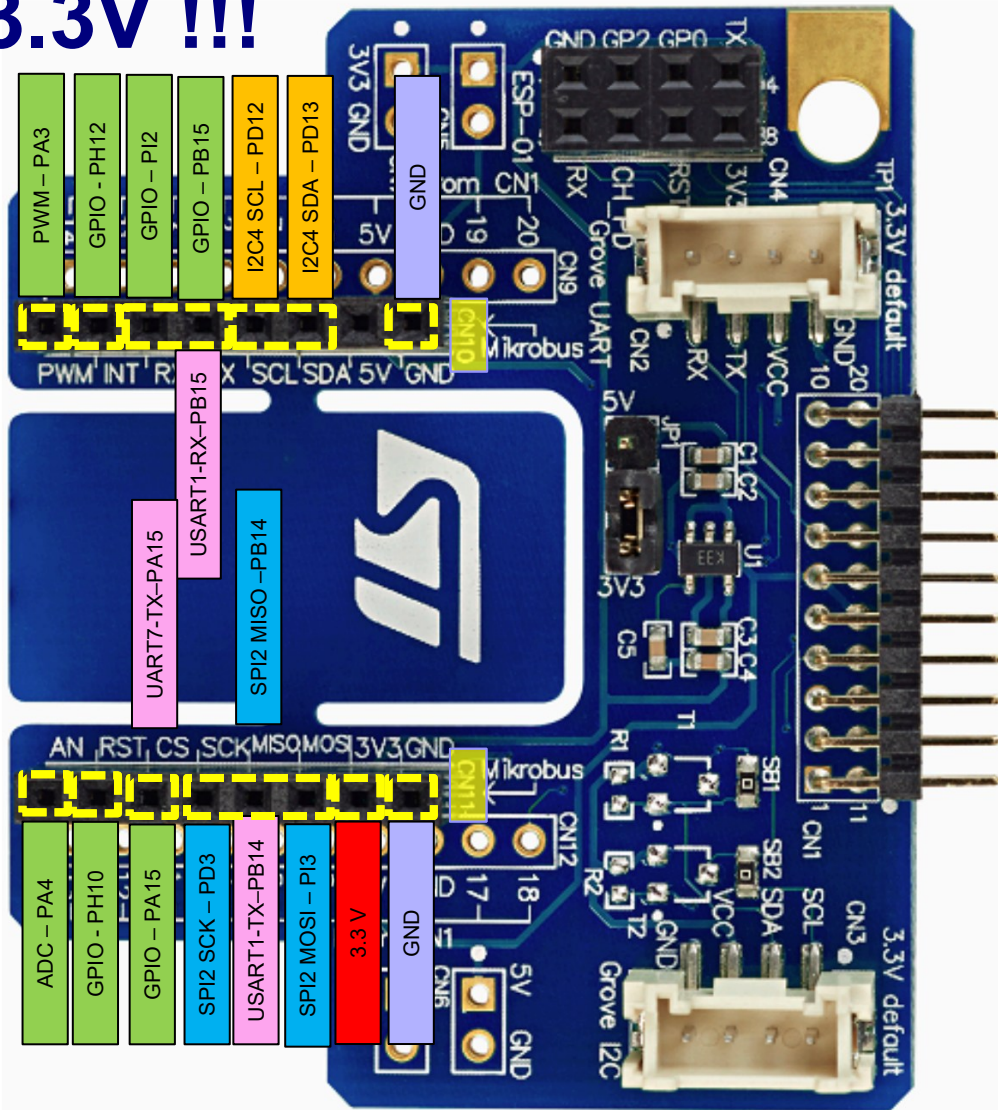
Testno vezje (primer) - STM32H7 :

GPIO	Vrsta	Povezava
PC13	User tipka	Modra tipka
PA4	Analogni vhod	Rumena žička
PH10	Dig. Vhod	Zelena žička
PA3	Dig. Izhod - LED	Oranžna žička
PJ2,PI13	Dig. Izhodi	vgr. LED diode

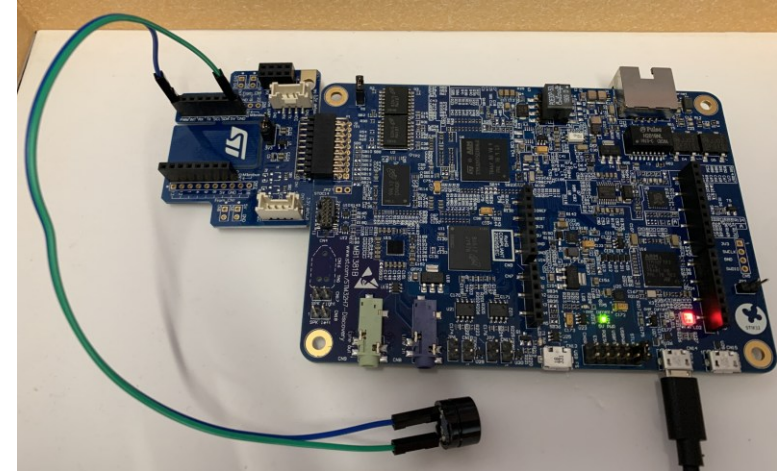


## STM32H750B – DISCOVERY StMod+ konektor

3.3V !!!



Pravilna priključitev



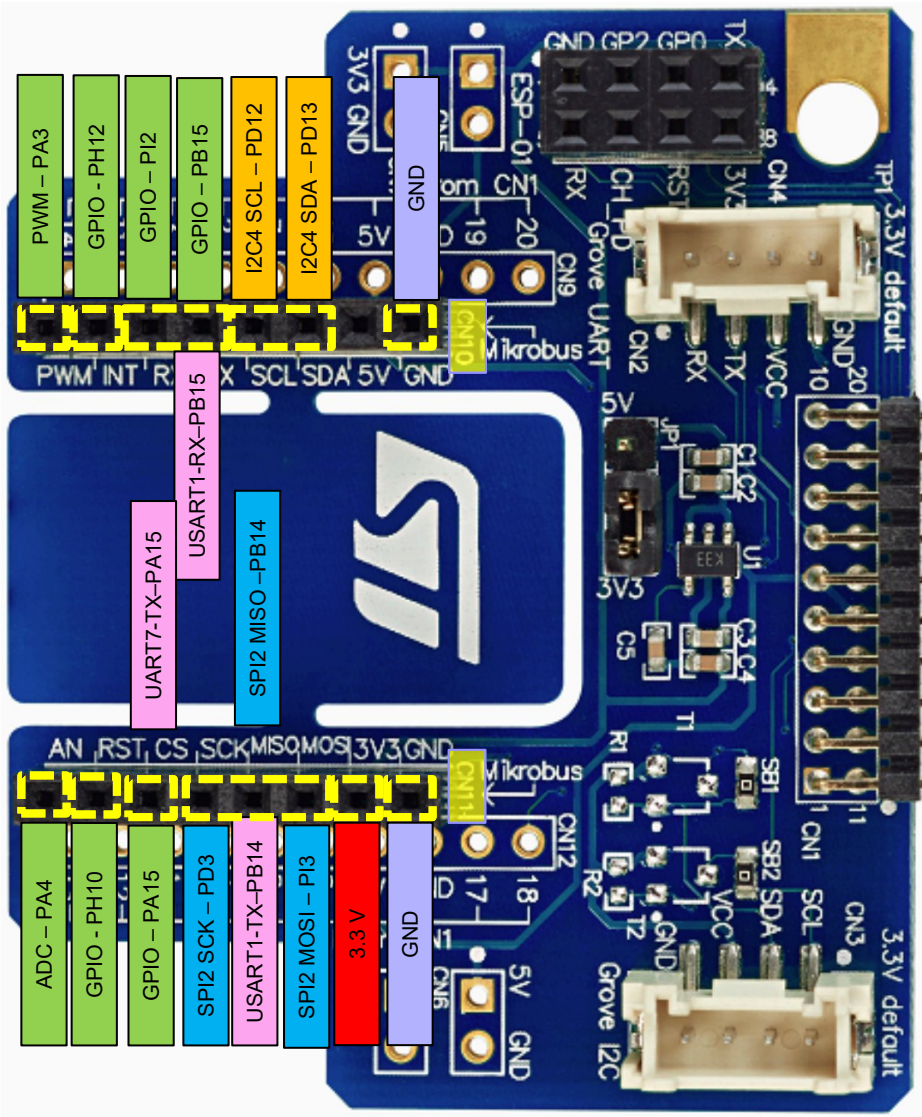
Nepravilna priključitev



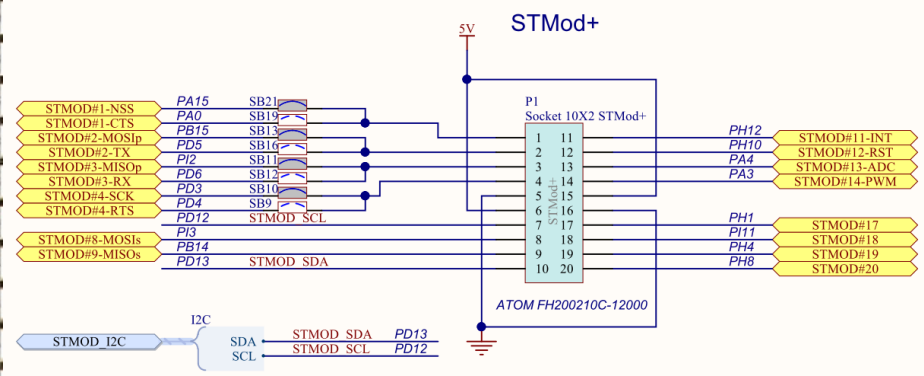
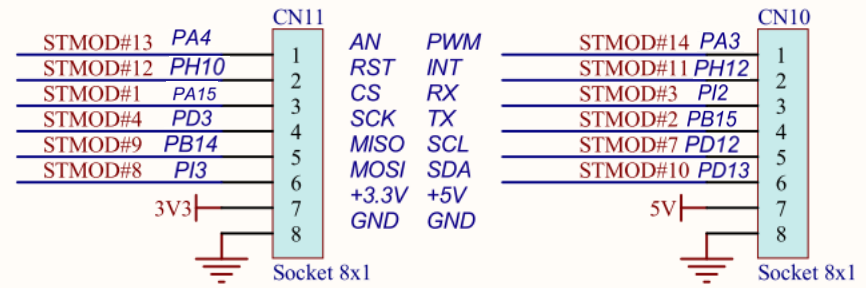
<https://www.st.com/en/evaluation-tools/stm32h750b-dk.html>

# 3.3V !!!

## STM32H750B – DISCOVERY StMod+ konektor



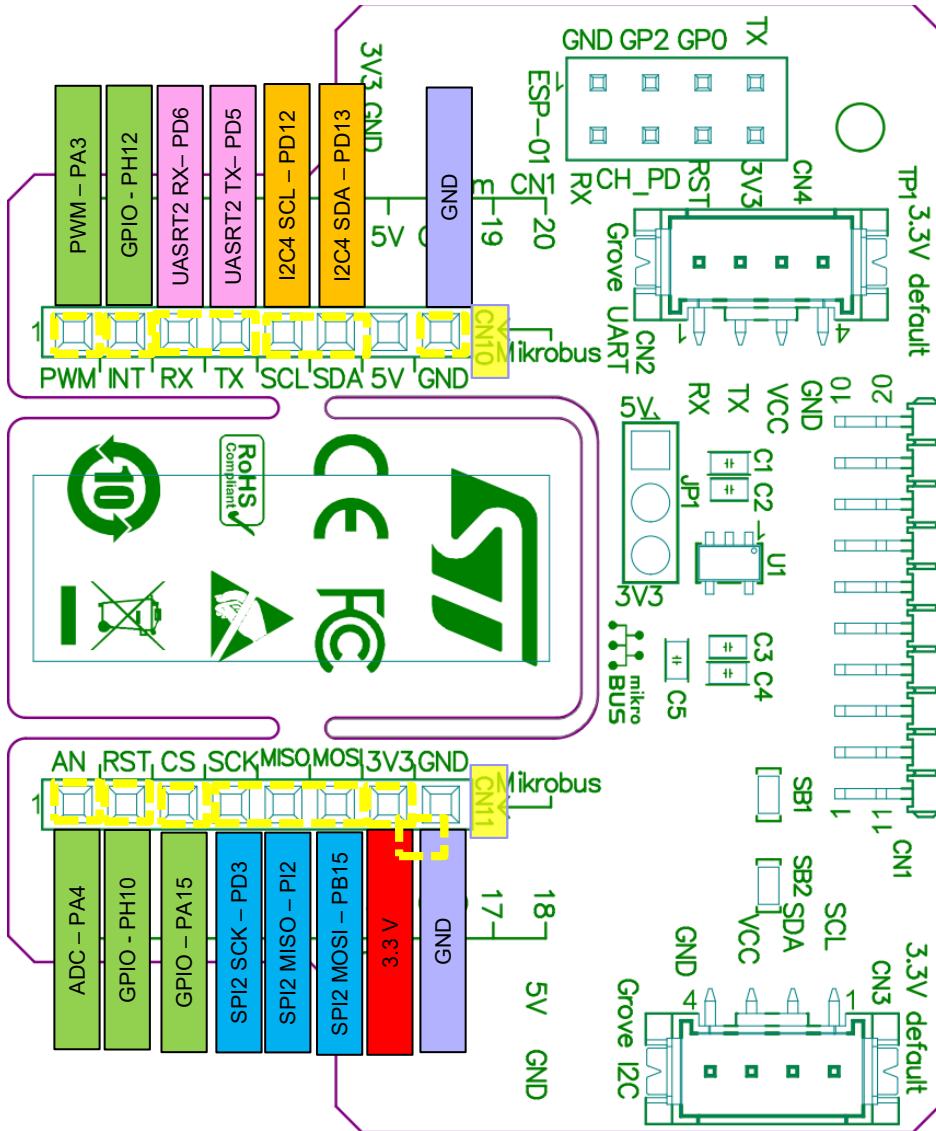
### Mikrobus connectors



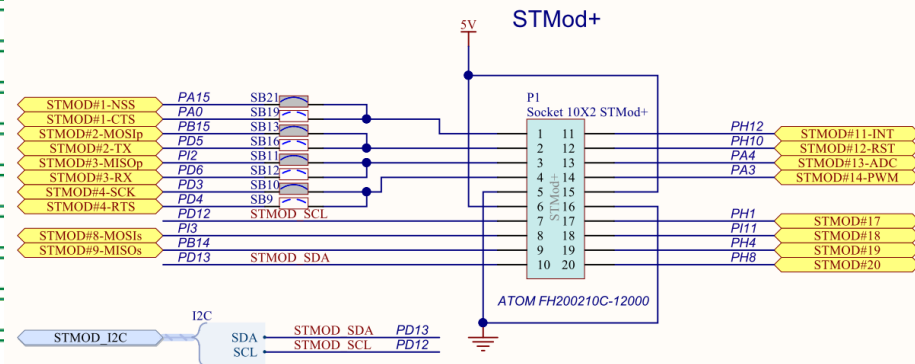
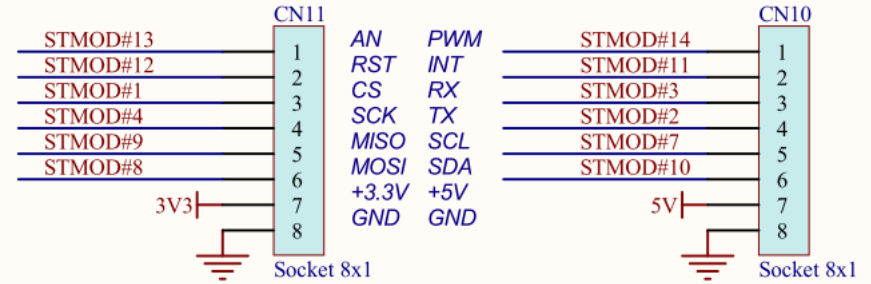
**STM32H7**

# 3.3V !!!

## STM32H750B – DISCOVERY StMod+ konektor



### Mikrobus connectors

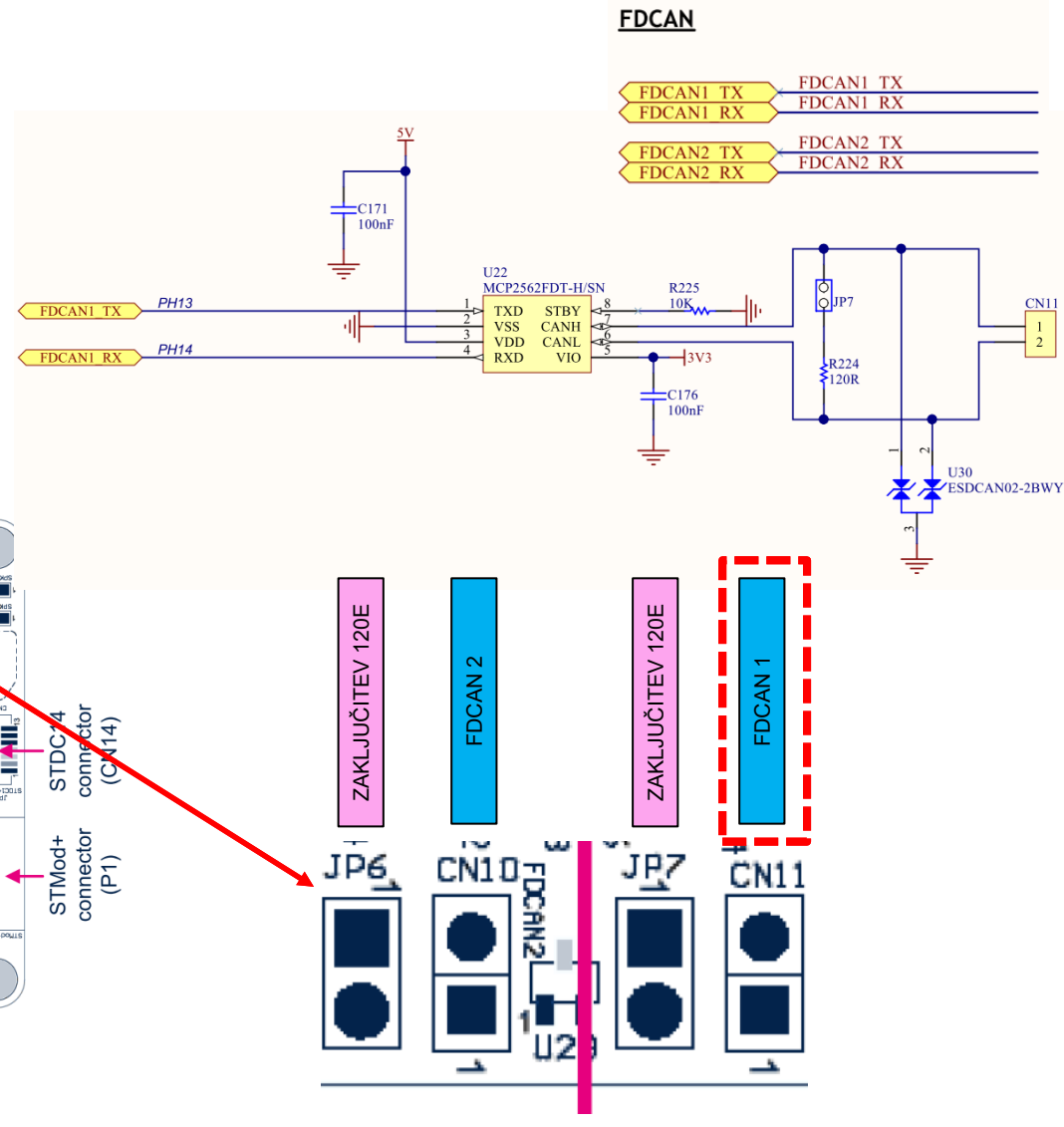
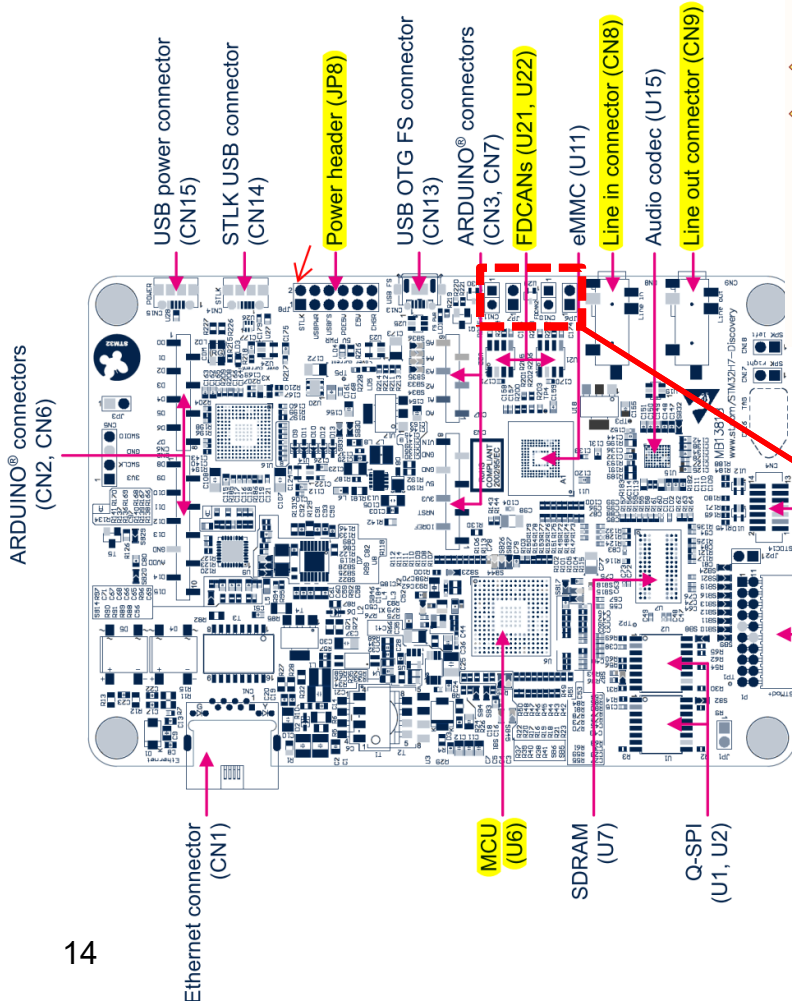


STM32H7

# 3.3V !!!

## STM32H750B – DISCOVERY CANBUS konektorja

### STM32H7



© Rozman - FRI

Figure 5. STM32H745I-DISCO and STM32H750B-DK Discovery board bottom layout

# 12.b VIN projekt in SensorTile.box

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- SensorTile.box (kompaktna razvojna platforma)
  - Edge Computing platforma
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# LAPSy Embedded Academy

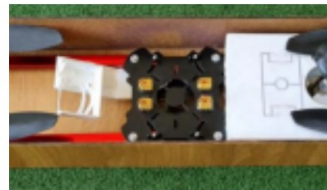
## LAPSy Embedded Academy - Home (sharepoint.com)



Študentski projekti pri predmetih RA, OR in VIN  
unij.sharepoint.com  
Različni študentski projekti iz prejšnjih šolskih let.



Tečaji, tutoriali ...  
unij.sharepoint.com  
Različni krajši tečaji z izbranimi tematikami



Diplomska dela  
unij.sharepoint.com  
Izbrana diplomska dela in ideje za teme

### Izbrani projekti (RA, OR, VIN)

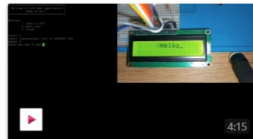
[See all](#)



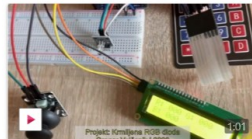
Forms  
Študentski projekti pri predmetih RA, OR in VIN (RAVINOR Projekti)\_Krajši...  
Rozman, Robert  
Edited Apr 13, 2024



Forms  
VIN PROJ 2023 Zaznavanje človeka z matrično termo kamero\_Jakob Jelovčan  
Rozman, Robert  
Edited Apr 8, 2024



Forms  
VIN PROJ 2023 STM32H7 in LCD-1602A\_Nejc Vene  
Rozman, Robert  
Edited Apr 8, 2024

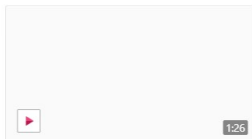


Forms  
VIN PROJ 2023 Krmiljena RGB dioda\_Gregor Volčanjek  
Rozman, Robert  
Edited Apr 8, 2024

1 of 12

### Ostale izbrane vsebine (diplome, tečaji, ...)

[See all](#)



Forms  
VSP DIPL 2023 Preizkušanje seizmografa s spustom uteži\_Luka Maček  
Rozman, Robert  
Edited Apr 26, 2024



Forms  
VSP DIPL 2024 Samodejni točilni sistem\_Bine Lipuš  
Rozman, Robert  
Edited Apr 26, 2024



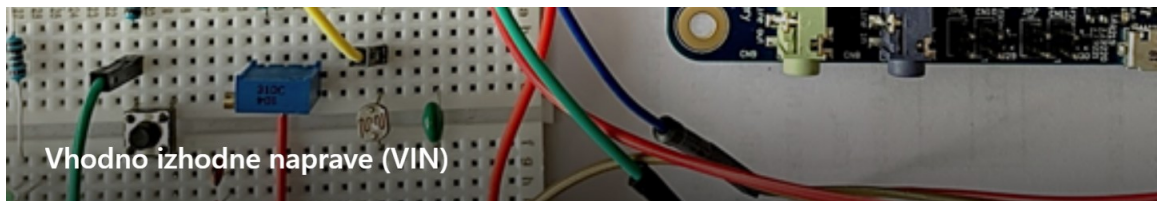
Forms  
VSP DIPL 2023 Biomimetična antropomorfna robotska roka\_Nejc...  
Rozman, Robert  
Edited Apr 26, 2024



Forms  
\_Izbrane diplomske naloge (Diplome)  
Rozman, Robert  
Edited Apr 26, 2024

# LAPSy Embedded Academy – VIN LAB

## Vhodno izhodne naprave (VIN) (sharepoint.com)



Laboratorijske vaje

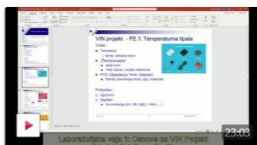
Priprava na izvedbo VIN projekta - STM32H7 (VIN LAB I)

See all



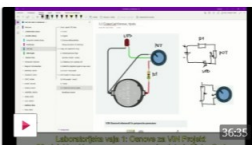
LAPSy Embedded Academy  
\_VIN LAB 01-06 Priprava na izdelavo VIN projekta (VIN-LAB Projekt)\_Krajši...

Rozman, Robert  
Edited April 15



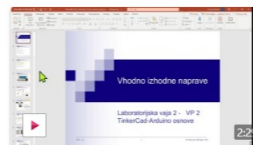
LAPSy Embedded Academy  
VIN LAB 01.01 Osnove za VIN Projekt\_Spolšno o tipalih.mp4

Rozman, Robert  
Edited April 15



LAPSy Embedded Academy  
VIN LAB 01.02 Osnove za VIN Projekt\_Uvod in osnovne vezave v...

Rozman, Robert  
Edited April 15



LAPSy Embedded Academy  
VIN LAB 02.01 TinkerCad in Arduino\_Uvod v potek LAB vaj.mp4

Rozman, Robert  
Edited April 15

1 of 12

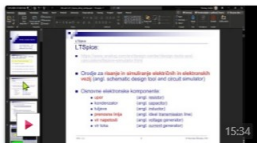
Praktične laboratorijske meritve z osciloskopi, generatorji (VIN LAB II)

See all



LAPSy Embedded Academy  
\_VIN LAB 07-12 Meritve odbojev, presluhov, očesnih vzorcev in tipal (VI...

Rozman, Robert  
Edited April 13



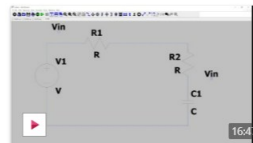
LAPSy Embedded Academy  
VIN LAB 07.01 AV1 - Simulacija vezij v orodju LTSpice\_Uvod v LTSpice.mp4

Rozman, Robert  
Edited April 13



LAPSy Embedded Academy  
VIN LAB 07.01 AV1 - Simulator vezij LTSpice\_Uvod v LTSpice.mp4

Rozman, Robert  
Edited April 8



LAPSy Embedded Academy  
VIN LAB 07.02 AV1 - Simulacija vezij v orodju LTSpice\_Osnovno vezje s...

Rozman, Robert  
Edited April 13

# LAPSy Embedded Academy – OneNote zvezek

[LAPSy Embedded Academy - Home \(sharepoint.com\)](#)

The screenshot shows a OneNote page with a dark-themed navigation bar at the top. The page title is "Preberi me" and the content area is mostly blank with a few small icons. On the right side, there is a table of contents pane with the following items:

- Preberi me
- Spletni viri
- Teme, področja
- Praktični izzivi v LAPSYLAB
  - STM32F4 Shield + Click boards
  - Clickboards
  - Model Hiške
    - Arduino Smart Home Kit
  - CANBUS - IEX modul
  - LSM6DSOX (30 kosov na voljo)
  - Breadboard samogradnja
  - Gibanje
  - Joystick
  - DIY osciloskop STM32
  - Arduino
  - Upornost/prevodnost kože
  - WS2812 Neopixel
  - How To Measure Water Tank Dept...
- Praktični izzivi
  - Clickboards (STM32H7,F4,Rp)
  - LTE IOT 2 CLICK (BG96)
  - STM32H750B DK + clickboards
  - STMod+ konektor
  - STM32F4 Shield + Click boards

# LAPSy Embedded Academy – MS Teams

The screenshot shows a Microsoft Teams channel page for 'LAPSy Embedded Academy'. The left sidebar contains navigation options like 'Domača stran', 'Class Notebook', and 'Glavni kanali'. The main content area is titled '8. Projekti' and displays a table of project items.

**8. Projekti** Objave Datoteke Notes

+ Novo Naloži Uredi v mrežnem pogledu Daj v skupno rabo Kopiraj povezavo Sinhronizacija

8. Projekti > Vsebine projektov

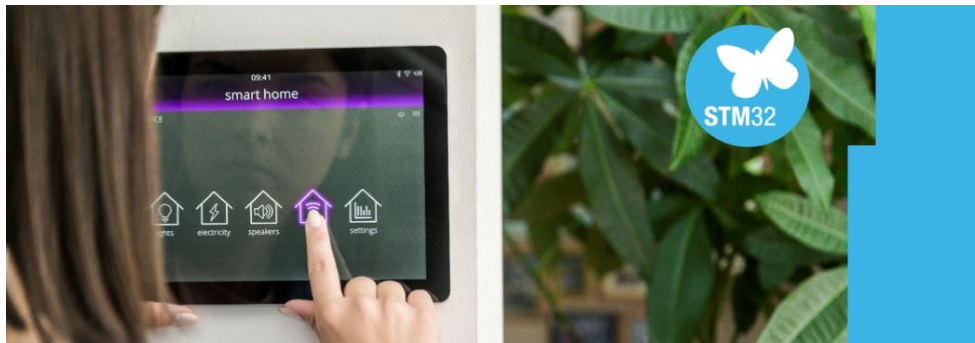
Name	Modified	Modified By	Video_channel	Item Child Count
STM32F4	April 24	Rozman, Robert		0
STM32H7	April 24	Rozman, Robert		0
VIN PROJ 2023 Analiza senzorjev CO2, tem...	April 24	Rozman, Robert		1
VIN PROJ 2023 APC1 in Arduino - Merjenje ...	April 24	Rozman, Robert		2
VIN PROJ 2023 Pametna IR kamera 8x8_Jak...	April 24	Rozman, Robert		4

**LAPSy Embedded Academy**

ty5qjm9

## Spletni viri

### Full range of STM32H7 training courses available online



### Full range of STM32H7 training courses available online

ST offers a full range of training courses in both **ePresentation** and **PDF** format for the STM32H7 series of High Performance MCUs. These courses provide helpful instructions and specific information on how to design applications that take advantage of the STM32H7's performance capabilities. More than 60 specific training modules focus on teaching the skills and knowledge for getting the most performance from STM32H7 MCUs for your applications.

Z naslova <[https://www.st.com/content/st\\_com/en/support/learning/stm32-education/stm32-online-training/stm32h7-online-training.html](https://www.st.com/content/st_com/en/support/learning/stm32-education/stm32-online-training/stm32h7-online-training.html)>

#### BSP STM32H750B-DK Component

Z naslova <<https://github.com/STMicroelectronics/stm32h750b-dk-bsp>>

**MOOC - STM32CubeIDE basics**

01 - Introduction

STMicroelectronics

13 videos 192,894 views Last updated on Jan 3, 2020

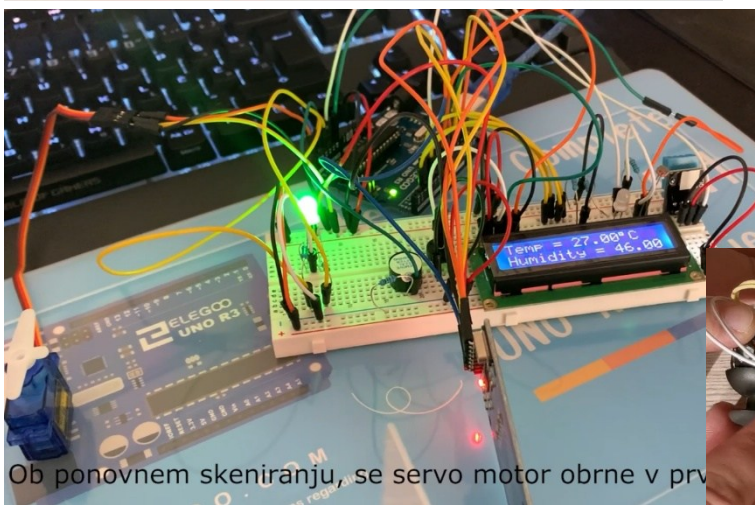
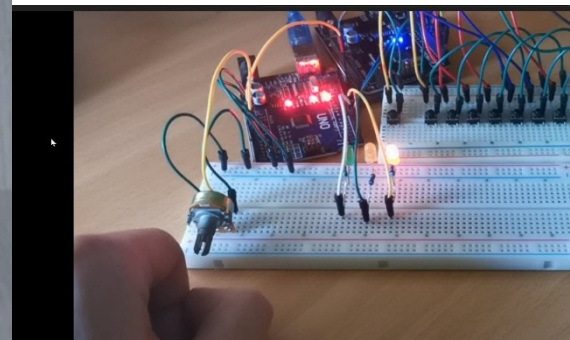
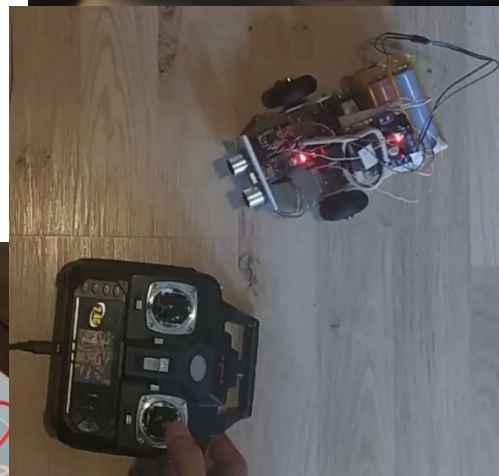
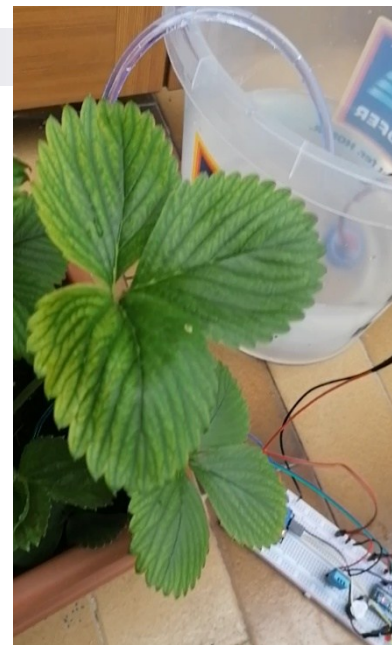
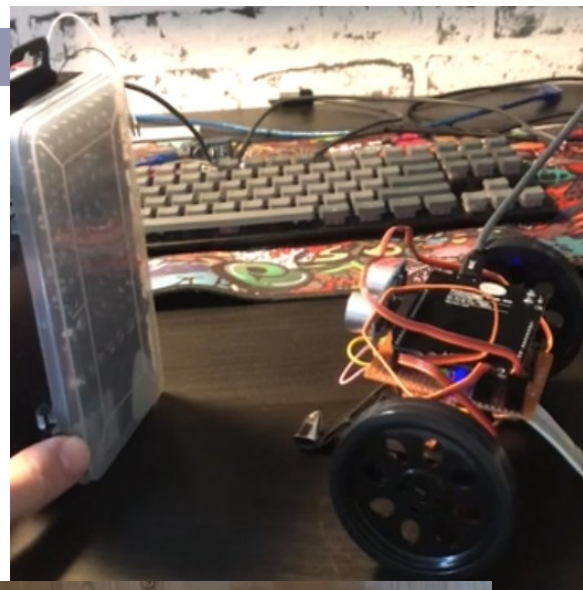
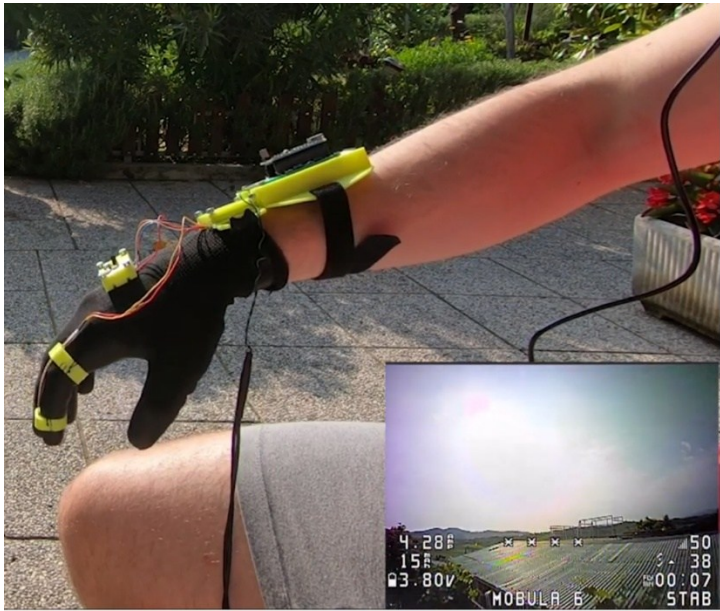
Play all Shuffle

Learn how to create your STM32 based application using STM32CubeIDE  
STM32CubeIDE can be used to create applications for STM32 devices using STM32Cube libraries (HAL and Low Layer versions).

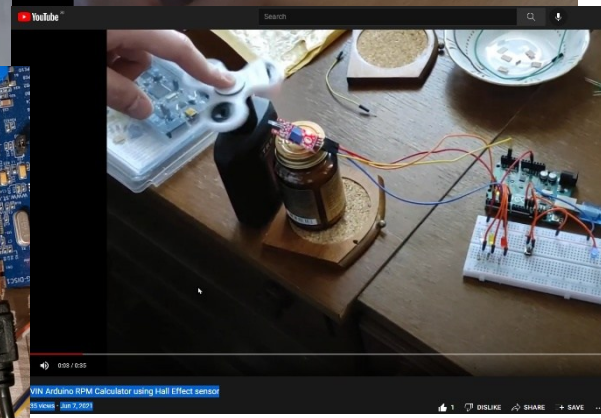
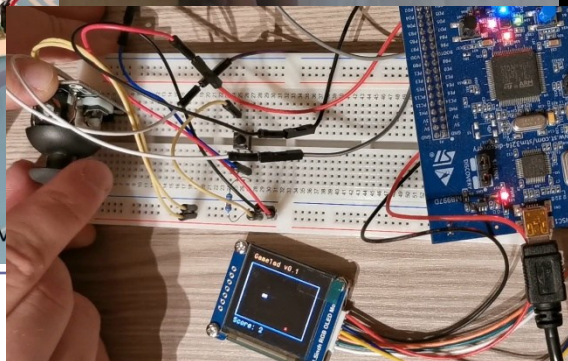
3 STM32CubeIDE basics - 03 GPIO HAL lab  
STMicroelectronics • 68K views • 3 years ago  
17:50

11 STM32CubeIDE basics - 11 USART HAL lab  
STMicroelectronics • 59K views • 3 years ago  
10:55

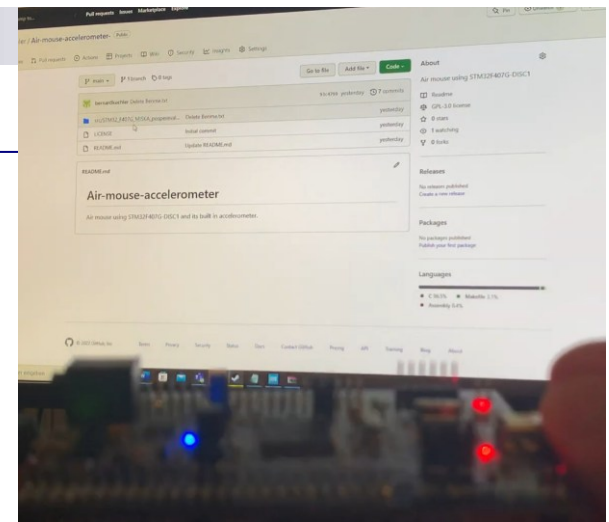
# VIN Projekti



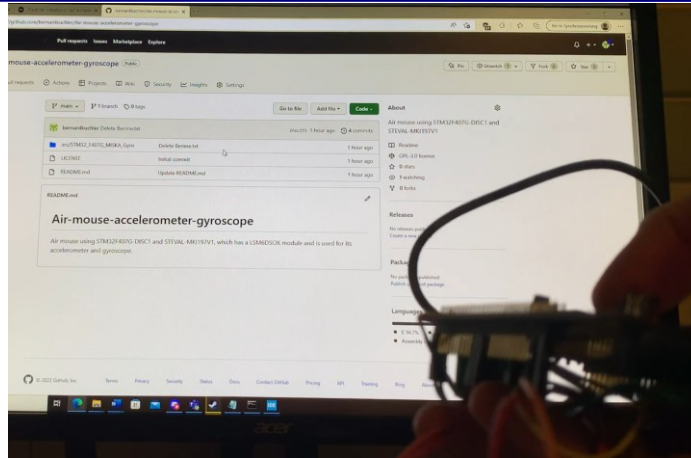
Ob ponovnem skeniranju, se servo motor obrne v prv



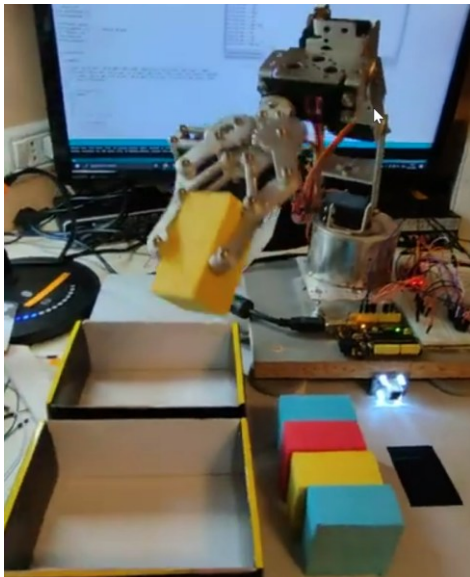
# VP – Primeri projektov STM32F4, H7 – 21/22



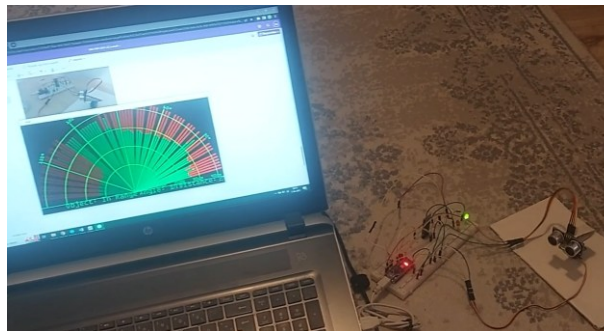
F4: Air Mouse



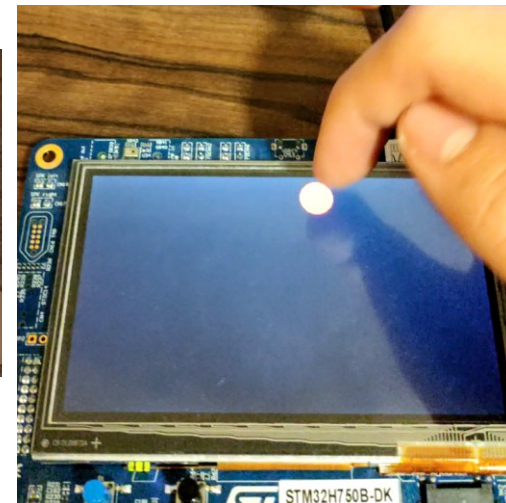
F4: LSM6DSOX – Air Mouse



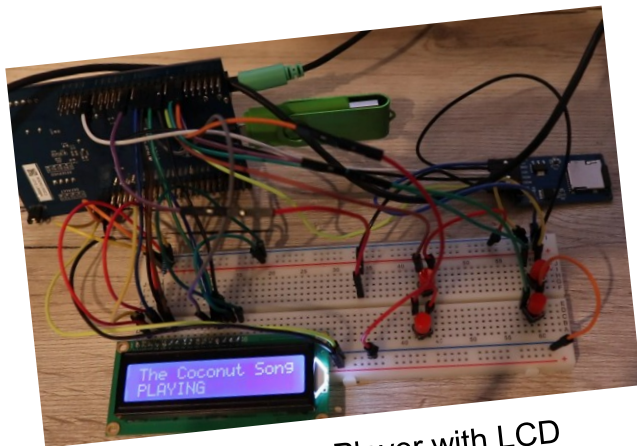
Robot: Colour Box sorter



3D Sonar



H7: Circle Popper



F4: Wave Player with LCD

[https://github.com/LAPSYLAB/STM32F4 Docs and Examples/](https://github.com/LAPSYLAB/STM32F4_Docs_and_Examples/)

## Termo kamera - LIR tipalo Smarteh

# Izzivi

Prilagam kratek dokument z navodili za priklop in zagotovitev pravilnega delovanja komunikacije med LIR-2 senzorjem ter osebnim računalnikom.

Poleg tega prilagam še link: <https://github.com/kolan51/ModbusLIR2example>, do GitHub repozitorija, kjer se nahaja osnovna python skripta, ki jo lahko uporabite, kot osnovo za izdelavo vaših lastnih projektov.

V navodilih je na koncu tudi kratek opis uporabe dodatnega projekta za barvni oziroma toplotni izris zajetih meritev, ki pa rabi še en minimalen popravek in ga bom poslal naknadno. Poleg naštetega prilagam še user manual za LIR-2, kjer je podrobnejši opis vseh registrov in samega delovanja.

Pošiljam še dodatni projekt kolega Domna, kot sem obljubil včeraj: [https://github.com/kolan51/LIR2\\_ColorTemp](https://github.com/kolan51/LIR2_ColorTemp). Lahko ga poganjate, kar preko .exe datoteke, navodila za uporabo projekta pa so ravno tako opisana v dokumentu, ki sem ga poslal včeraj. Tudi ta projekt lahko uporabite kot osnovo za nadaljnje delo.

[VIN PROJ 2023 Pametna IR kamera 8x8 Jakob Jelovčan](#)

[Smarteh LIR2 Tipalo](#)

[VIN PROJ 2023 Pametna IR kamera 8x8 Jakob Jelovčan](#)

[VIN PROJ 2023 Zaznavanje človeka z matrično termo kamero Jakob\\_jelovčan.mp4](#)

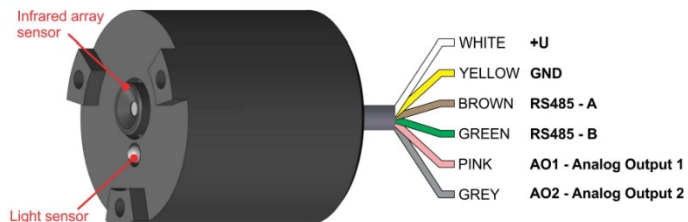
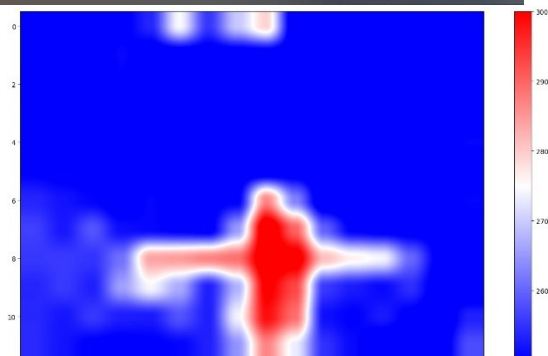
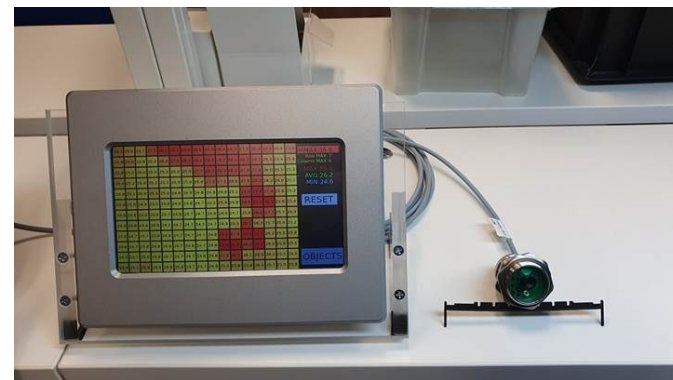


Table 1: Features

Infrared array sensor 12 x 16 Pixel
Light indication
Modbus RTU communication protocol
2 analog outputs 0 .. 10 V
IP65



```
Windows PowerShell
PS C:\Users\Jakob\git\LIR2> python3 .\classifier.py models/convolutional_model.pt -s COM4 -d
Person present: True
```

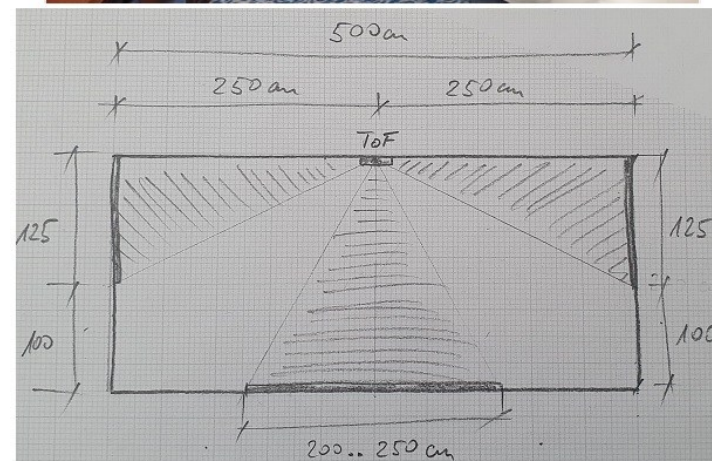
# Izzivi

## Zaznavanje potnikov v ladijski kabini - Smarteh

a.) kot prvi, in upam da ne prezahteven cilj, bi želeli razviti **algoritem za detekcijo ljudi v prostoru**. Tukaj nas še ne bi zanimalo število ljudi, pač pa samo njihova prisotnost, tudi če so v "mirovanju->spanje". Klasični PIR senzor tukaj odpove, in to bi radi nadgradili za potniške kabine na ladji (sliki v priponki, številke v kvadratih so razdalje v mm).

b.) kot drugi korak pa bi poiskovali **detektirati število ljudi v prostoru**. Ja, ta del bo zahtevnejši, mogoče za začetek, če uspemo prepoznati enega, dva in več kot dve osebi.

Oboje bi morali znati implementirati na napravi sami (matrični termo senzor obdelujemo na enem od ST ukontroler-jev), kar pomeni delo z omejenimi resurci -> implementacija preprostejših algoritmov. Obdelava pa PC-ju tukaj odpade, razen v začetni fazi -> fazi učenja pred fazo optimizacije.



**Flight Sense**

### Recommended products: VL53L7CX and VL53L8CX selection guide

	<b>VL53L7CX</b>	<b>VL53L8CX</b>
Field of view	<b>60° x 60° (90° diagonal)</b>	45° x 45° (65° diagonal)
Resolution	Up to 8x8 (64 zones)	
Common features	Autonomous low power mode	
Additional features	External synchronization pin	
Driver	100% compatible	
Interfaces	I <sup>2</sup> C (1 MHz)	I <sup>2</sup> C (1 MHz) and <b>SPI (3 MHz)</b>
Distance ranging	Dark condition	350 cm
	Under ambient light*	<b>65 cm</b>
Power consumption**	4.5mW	<b>1.6mW</b>
Module size	6.4 x 3.0 x 1.6 mm	6.4 x 3.0 x 1.75 mm

\* Best conditions using white target (88% reflectance)  
\*\* Power consumption measured at 1Hz frequency and with 3.3 V analog and VCSEL supply

STMicroelectronics

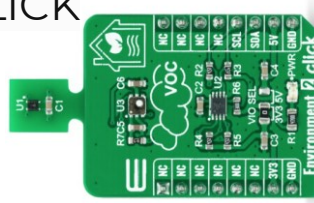
# Primer uporabe virov: Podatkovne listine, knjižnice, ...

## ENVIRONMENT 2 CLICK

**PID:** MIKROE-4558

**Weight:** 20 g

**Environment 2 Click** is a compact add-on board containing best-in-class SHT humidity and SGP air-quality sensing solutions from [Sensirion](https://www.sensirion.com). This board features [SHT40](#) and [SGP40](#), a high-accuracy ultra-low-power relative humidity, and a temperature sensor combined with MOx based gas sensor. ...



<b>Interface</b>	I2C
------------------	-----

Z naslova <<https://www.mikroe.com/environment-2-click>>



**Programska knjižnica**  
Delujoča demo koda

We provide a [library for the Environment 2 Click](#) as well as a [demo application \(example\)](#), developed using MikroElektronika [compilers](#). The demo can run on all the main MikroElektronika [development boards](#). ...

### Library Description

This library contains API for Environment 2 Click driver. Key functions:

• `environment2_cfg_setup` - Config Object Initialization function.

• `environment2_init` - Initialization function.

• `environment2_default_cfg` - Click Default Configuration function.

Z naslova <<https://www.mikroe.com/environment-2-click>>

**Podatkovna listina (Datasheet)**  
Vsebuje informacije o tipalu...

**SENSIRION**  
THE SENSOR COMPANY

### Preliminary Datasheet SGP40

Indoor Air Quality Sensor for VOC Measurements

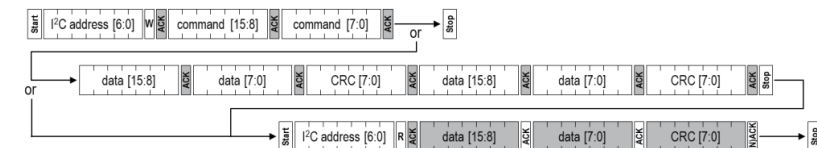
#### 4 Digital Interface Description

##### 4.1 General Considerations

For driver integration incl. utilization of Sensirion's VOC Algorithm, please refer to the application note *SGP40 Driver Integration (for Dedicated I<sup>2</sup>C Hardware)*. All SGP40 commands consist of two bytes (16 bits). The commands must not be followed by a CRC. Additionally, data sent to and returned from the sensor is transferred in packets of two bytes (16 bits) followed by a 1-byte (8 bit) CRC.

##### 4.2 I<sup>2</sup>C Address

The sensor's I<sup>2</sup>C address is 89 (decimal; hex.: 0x59). The I<sup>2</sup>C header is formed by the I<sup>2</sup>C address followed by a read or write bit.



**Figure 10** Possible I<sup>2</sup>C command sequences for communicating with the SGP40. Dark areas indicate that the sensor controls the SDA (data) line. First, the I<sup>2</sup>C master sends the write header writing a 16-bit command, potentially followed by two words of data with CRC bytes. For reading the measured data, the I<sup>2</sup>C master sends the read header and receives one word of data with CRC byte.

##### 4.7 I<sup>2</sup>C Commands

The available measurement commands of the SGP40 are listed in [Table 8](#).

Command	Command hex. code	Parameter length including CRC [bytes]	Response length including CRC [bytes]	Measurement duration [ms]	
				Typ.	Max.
<code>sgp40_measure_raw</code>	0x26 0F	6	3	25	30
<code>sgp40_measure_test</code>	0x28 0E	-	3	240	250
<code>sgp40_heater_off</code>	0x36 15	-	-	0.1	1

**Table 8** I<sup>2</sup>C commands available for SGP40.

# 12.b VIN projekt in SensorTile.box

- Praktična naloga - VIN Projekt
  - Razvojne plošče
  - Viri (gradiva, posnetki, primeri, ...)
  - Osnovna projekta v CubeIDE:
    - CubeMX (HAL knjižnica, BSP) – STM32H7, STM32F4
      - CubeMX – osnovni projekt (GPIO – tipka, LED diode, USART)
      - BSP – osnovni projekt (Touch, LCD)
- SensorTile.box (kompaktna razvojna platforma)
  - Edge Computing platforma
- STM AI ekosistem in Orange Data Mining

## Baremetal - zbirnik

## Baremetal - C

## HAL - C

```
INIT_IO:
push {r5, r6, lr}
// Enable GPIO Peripheral Clock (bit 3 in AHB1ENR register)
ldr r6, =RCC_AHB1ENR // Load peripheral clock reg address to r6
ldr r5, [r6] // Read its content to r5
orr r5, 0x00000008 // Set bit 3 to enable GPIO clock
str r5, [r6] // Store result in peripheral clock register

// Make GPIO Pin12 as output pin (bits 25:24 in MODER register)
ldr r6, =GPIO_BASE // Load GPIO BASE address to r6
ldr r5, [r6,#GPIO_MODER] // Read GPIO_MODER content to r5
and r5, 0x00FFFFFF // Clear bits 31-24 for P12-15
orr r5, 0x55000000 // Write 01 to bits 31-24 for P12-15
str r5, [r6] // Store result in GPIO MODER register
pop {r5, r6, pc}
```

```
LED_ON:
push {r5, r6, lr}
// Set GPIO Pins to 1 (through BSSR register)
ldr r6, =GPIO_BASE // Load GPIO BASE address to r6
mov r5, #LEDs_ON
str r5, [r6,#GPIO_BSSR] // Write to BSSR register
pop {r5, r6, pc}
```

```
LED_OFF:
push {r5, r6, lr}
// Set GPIO Pins to 0 (through BSSR register)
ldr r6, =GPIO_BASE // Load GPIO BASE address to r6
mov r5, #LEDs_OFF
str r5, [r6,#GPIO_BSSR] // Write to BSSR register
pop {r5, r6, pc}
```

[https://github.com/LAPSYLAB/ORLab-STM32/tree/main/GPIO\\_LEDs](https://github.com/LAPSYLAB/ORLab-STM32/tree/main/GPIO_LEDs)

RA, OR

[https://github.com/LAPSYLAB/STM32F4\\_Discovery\\_VIN\\_Projects/tree/main/LED\\_GPIO\\_C\\_Baremetal\\_C](https://github.com/LAPSYLAB/STM32F4_Discovery_VIN_Projects/tree/main/LED_GPIO_C_Baremetal_C)

VIN

[https://github.com/LAPSYLAB/STM32F4\\_Discovery\\_VIN\\_Projects/tree/main/LED\\_Blink\\_Demo](https://github.com/LAPSYLAB/STM32F4_Discovery_VIN_Projects/tree/main/LED_Blink_Demo)

```
/* USER CODE BEGIN 2 */

RCC->AHB1ENR |= 0x08;
// Enable clock for GPIO
GPIO->MODER |= 0x01000000; //
MODE Register: bit 12 == out

/* USER CODE END 2 */

/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
GPIO->ODR ^= 0x1000; //
Toggle PD12

/* USER CODE END WHILE */

/* USER CODE BEGIN 3 */
for (int i=0; i<0x100000; i++) {};
// waste some time
}
/* USER CODE END 3 */
```

```
/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
HAL_GPIO_TogglePin(GPIO, GPIO_PIN_12);

/* USER CODE END WHILE */

/* USER CODE BEGIN 3 */
HAL_Delay(1000);
}
/* USER CODE END 3 */

void HAL_GPIO_TogglePin(GPIO_TypeDef* GPIOx,
uint16_t GPIO_Pin)
{
uint32_t odr;

/* Check the parameters */
assert_param(IS_GPIO_PIN(GPIO_Pin));

/* get current Output Data Register value
*/
odr = GPIOx->ODR;

/* Set selected pins that were at low
level, and reset ones that were high */
GPIOx->BSRR = ((odr & GPIO_Pin) <<
GPIO_NUMBER) | (~odr & GPIO_Pin);
}
```

# Vir: UM2217 - HAL and Low-layer drivers

UM2217

User manual

## Programska knjižnica

Vsebuje predpripravljene funkcije za delo s sistemskimi in V/I napravami.



This section contains the following APIs:

- `HAL_Init()`
- `HAL_DeInit()`
- `HAL_MspInit()`
- `HAL_MspDeInit()`
- `HAL_InitTick()`



## Description of STM32H7 HAL and low-layer drivers

This section contains the following APIs:

- `HAL_IncTick()`
- `HAL_GetTick()`
- `HAL_GetTickPrio()`
- `HAL_SetTickFreq()`
- `HAL_GetTickFreq()`
- `HAL_Delay()`
- `HAL_SuspendTick()`
- `HAL_ResumeTick()`
- `HAL_GetHalVersion()`

This section contains the following APIs:

- `HAL_USART_Transmit()`
- `HAL_USART_Receive()`
- `HAL_USART_TransmitReceive()`
- `HAL_USART_Transmit_IT()`
- `HAL_USART_Receive_IT()`
- `HAL_USART_TransmitReceive_IT()`
- `HAL_USART_Transmit_DMA()`
- `HAL_USART_Receive_DMA()`
- `HAL_USART_TransmitReceive_DMA()`

### 35.2.4

#### IO operation functions

This section contains the following APIs:

- `HAL_GPIO_ReadPin()`
- `HAL_GPIO_WritePin()`
- `HAL_GPIO_TogglePin()`
- `HAL_GPIO_LockPin()`
- `HAL_GPIO_EXTI_IRQHandler()`
- `HAL_GPIO_EXTI_Callback()`

This section contains the following APIs:

- `HAL_I2C_Init()`
- `HAL_I2C_DeInit()`
- `HAL_I2C_MspInit()`
- `HAL_I2C_MspDeInit()`
- `HAL_I2C_RegisterCallback()`
- `HAL_I2C_UnRegisterCallback()`
- `HAL_I2C_RegisterAddrCallback()`
- `HAL_I2C_UnRegisterAddrCallback()`

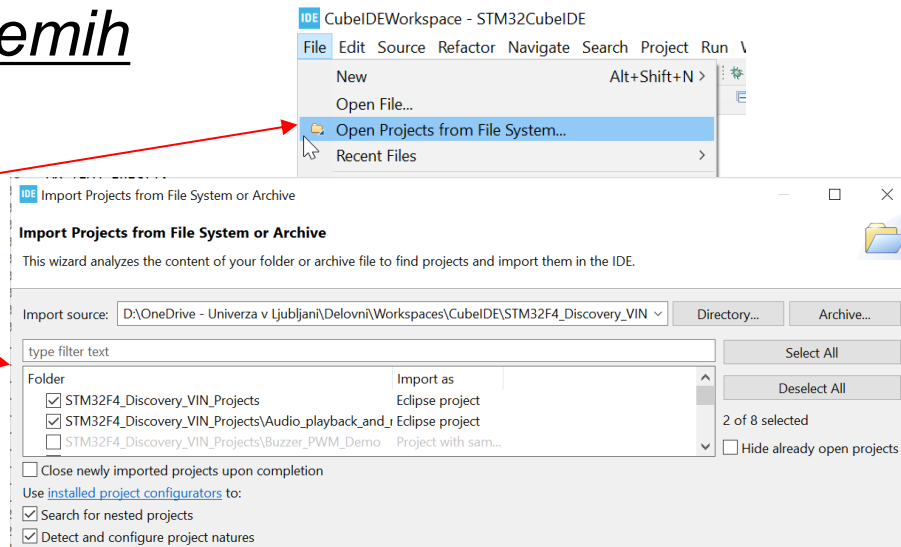
UM2217 - Rev 6

page 2/4020

# CubeIDE: delo na STM32 sistemih

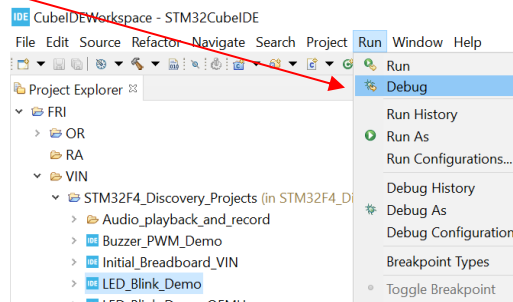
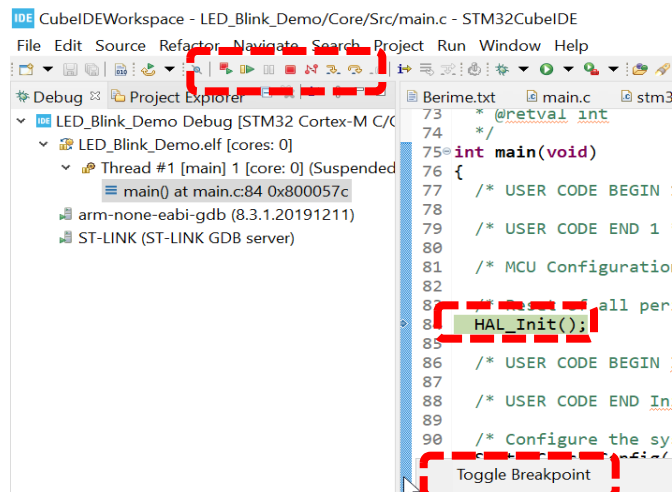
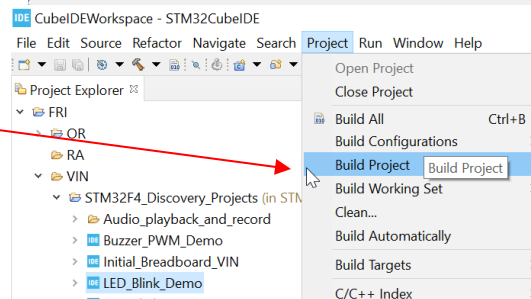
## Vzpostavitev začetnega projekta :

- **Uvoz obstoječega (npr. BSP)**
  - Open projects from File System
  - Select project(s)
- **Nov projekt CubeMX ->**  
(v nadaljevanju)



## Prevajanje, zagon :

- Project -> Build Project
- Run -> Debug
- Step (Into, Over), Breakpoints



# CubeIDE: delo na STM32 sistemih

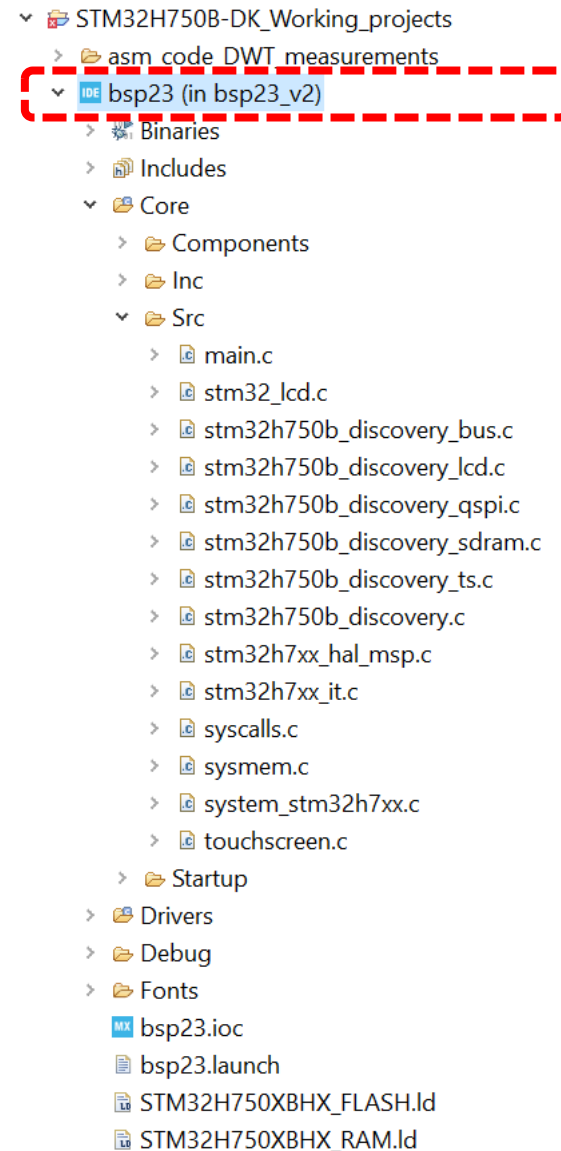
## Kopiranje projekta :

### •Kopiranje CubeIDE projekta z CubeMX .ioc datoteko

- 1) Edit > **Copy (obstoječi projekt).**
- 2) Edit > **Paste (nova lokacija).**
- 3) Preimenuj .ioc datoteko.
- 4) Zbriši **Debug.launch** datoteko.
- 5) Project > **Clean.**
- 6) Generiraj kodo s **CubeMX.**
- 7) Project > **Build** Project.
- 8) Debug As Stm32 Application.
- 9) **Debug** aplikacije.
- 

### •Kopiranje osnovnih CubeIDE asm,BSP C projekta

- 1) Edit > **Copy (obstoječi projekt).**
- 2) Edit > Paste **(nova lokacija).**
- 3) Delete the Debug.launch file.
- 4) Project > Clean.
- 5) Project > Build Project.
- 6) Debug As Stm32 Application.
- 7) And debug the application
- 8) Add breakpoint on first instruction if necessary



# 12.b VIN projekt in SensorTile.box

## ■ Praktična naloga - VIN Projekt

- Razvojne plošče
- Viri (gradiva, posnetki, primeri, ...)
- Osnovna projekta v CubeIDE:

- CubeMX (HAL knjižnica, BSP) – STM32H7, STM32F4

- CubeMX – osnovni projekt (GPIO – tipka, LED diode, USART)
- BSP – osnovni projekt (Touch, LCD)

## ■ SensorTile.box (kompaktna razvojna platforma)

- Edge Computing platforma

## ■ STM AI ekosistem in Orange Data Mining

# Delo na STM32H7 razvojnem sistemu

Mikro USB priključek na daljši stranici (srednji !!!) ↓

Priključitev :

- Mikro USB priključek na daljši stranici (srednji !!!)

Poseben začetni projekt in info za STM32H7 (e-učilnica,github):

- dodajanje vsebine (main.c):



```
CubelDEWorkspace - Sluzba/ORLab-STM32H7/STM32H750B-DK_C_Basic/Core/Src/main.c - STM32CubelDE
File Edit Source Refactor Navigate Search Project Run Window Help
Project Explorer
CubelDE_Workspace
Delo
Node_V4 (in node_v4)
Sluzba
  CAN_IEX_Module
  CAN_IEX_Module_bak
  H7-BSP-LCD-OS
  ORLab-STM32
  ORLab-STM32H7
    Docs
    DWT_Cycles_Measurements
    GPIO_LEDs
    STM32H750B-DK_C_Basic
      Core
        Inc
        Src
main.c
131
132 /* Infinite loop */
133 /* USER CODE BEGIN WHILE */
134 while (1)
135 {
136     HAL_GPIO_TogglePin(GPIOI, GPIO_PIN_13);
137     HAL_GPIO_TogglePin(GPIOJ, GPIO_PIN_2);
138
139     /* USER CODE END WHILE */
140
141     /* USER CODE BEGIN 3 */
142     snprintf (SendBuffer,BUFSIZE,"USART3:%d secs\r\n",Cnt);
143     HAL_UART_Transmit(&huart3,SendBuffer,strlen(SendBuffer),1);
144
145     HAL_Delay(1000);
146     Cnt++;
147 }
148 /* USER CODE END 3 */
149 }
150
```



Lastni viri :

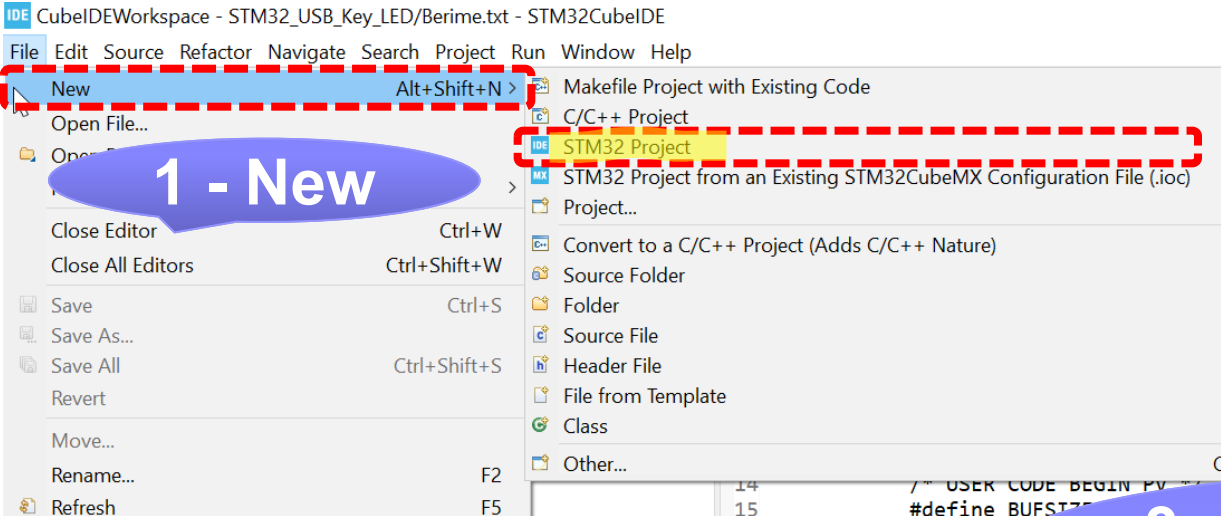
[https://github.com/LAPSyLAB/STM32H7\\_Discovery\\_VIN\\_Projects](https://github.com/LAPSyLAB/STM32H7_Discovery_VIN_Projects)

<https://github.com/LAPSyLAB/ORLab-STM32H7>



# CubeIDE – Vzpostavitev novega projekta s CubeMX

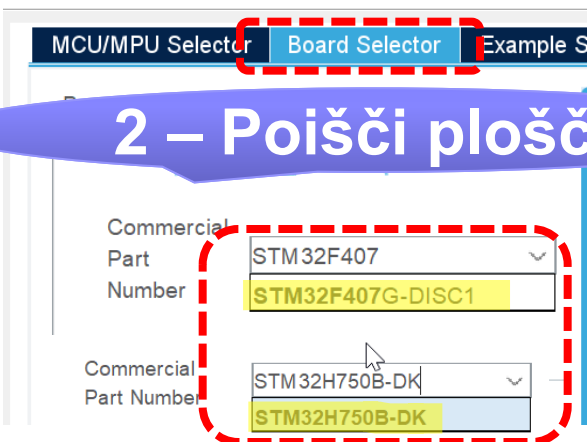
## Nov projekt :



STM32 Project

## Target Selection

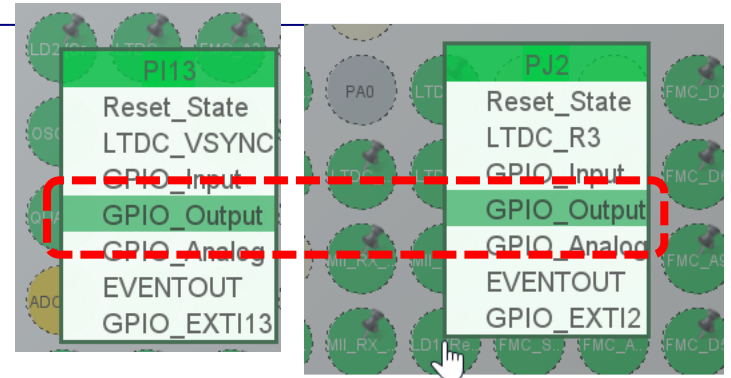
STM32 target or STM32Cube example selection is required



# STM32H7

## Osnovni projekt CubeIDE – CubeMX

### Konfiguracija : priključki, knjižnice STM32H7



STM32Cube MCU packages and embedded software packs

- Copy all used libraries into the project folder
- Copy only the necessary library files
- Add necessary library files as reference in the toolchain project configuration file

Generated files

- Generate peripheral initialization as a pair of '.c/.h' files per peripheral
- Backup previously generated files when re-generating
- Keep User Code when re-generating
- Delete previously generated files when not re-generated

HAL Settings

- Set all free pins as analog (to optimize the power consumption)
- Enable Full Assert

Template Settings

Select a template to generate customized code

Settings...

Project Settings

Project Name: LED\_GPIO\_C\_Baremetal\_C

Project Location: D:\Delovni\CubeIDE\CubeIDE\workspace

Application Structure: Advanced  Do not generate the main()

Toolchain Folder Location: D:\Delovni\CubeIDE\CubeIDE\workspace\LED\_GPIO\_C\_Baremetal\_C

Toolchain / IDE: STM32CubeIDE  Generate Under Root

Linker Settings

Minimum Heap Size: 0x200

Minimum Stack Size: 0x400

Thread-safe Settings

Cortex-M4NS

- Enable multi-threaded support

Thread-safe Locking Strategy: Default - Mapping suitable strategy to

McU and Firmware Package

Mcu Reference: STM32F407VGTx

Firmware Package Name and Version: STM32Cube FW\_F4\_V1.28.2

Advanced Settings

Generated Function Calls

Generate Code	Rank	Function Name	Peripheral Instance Name	Do Not Generate Function Call
<input checked="" type="checkbox"/>	1	SystemClock_Config	RCC	<input type="checkbox"/>
<input checked="" type="checkbox"/>	2	MX_GPIO_Init	GPIO	<input type="checkbox"/>
<input checked="" type="checkbox"/>	3	MX_ADC1_Init	ADC1	<input type="checkbox"/>
<input checked="" type="checkbox"/>	4	MX_ADC2_Init	ADC2	<input type="checkbox"/>
<input checked="" type="checkbox"/>	5	MX_ADC3_Init	ADC3	<input type="checkbox"/>
<input checked="" type="checkbox"/>	6	MX_ETH_Init	ETH	<input type="checkbox"/>
<input checked="" type="checkbox"/>	7	MX_FDCAN1_Init	FDCAN1	<input type="checkbox"/>
<input checked="" type="checkbox"/>	8	MX_FDCAN2_Init	FDCAN2	<input type="checkbox"/>
<input checked="" type="checkbox"/>	9	MX_FMC_Init	FMC	<input type="checkbox"/>
<input checked="" type="checkbox"/>	10	MX_LTDC_Init	LTDC	<input type="checkbox"/>
<input checked="" type="checkbox"/>	11	MX_QUADSPI_Init	QUADSPI	<input type="checkbox"/>
<input checked="" type="checkbox"/>	12	MX_RTC_Init	RTC	<input type="checkbox"/>
<input checked="" type="checkbox"/>	13	MX_SAI2_Init	SAI2	<input type="checkbox"/>
<input checked="" type="checkbox"/>	14	MX_SDMMC1_MMC_Init	SDMMC1	<input checked="" type="checkbox"/>



4 – Preveri nastavitve

# STM32H7

## Osnovni projekt CubeMX – USB Virtual COM

Program : za pošiljanje po USB Virtual COM Port (USART3)

```
/* Private variables ----- */

/* USER CODE BEGIN PV */
#define    BUFSIZE 256
char      SendBuffer[BUFSIZE];
int       Counter;
/* USER CODE END PV */

/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
    /* USER CODE END WHILE */

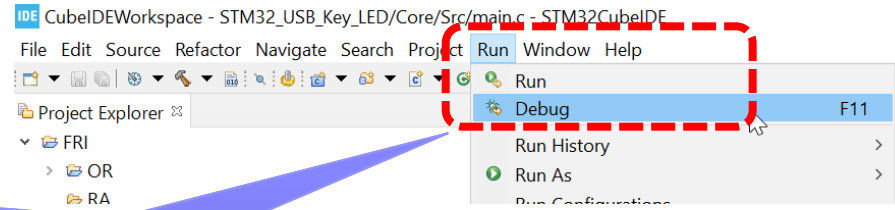
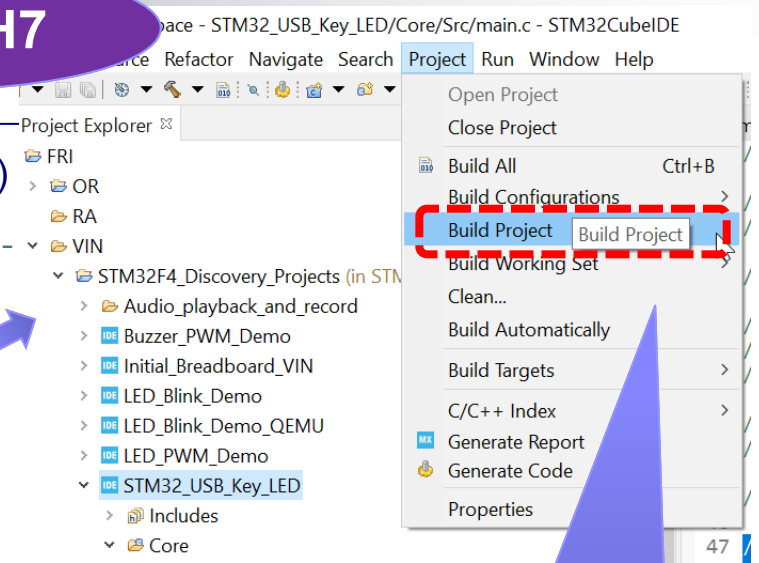
    /* USER CODE BEGIN 3 */
    snprintf (SendBuffer, BUFSIZE, "USART3:%d secs\r\n", Counter);
    HAL_UART_Transmit(&huart3, SendBuffer, strlen(SendBuffer), 100);

    HAL_Delay(1000);
    Counter++;
}
/* USER CODE END 3 */
```

5 – UART koda

6 – Build project

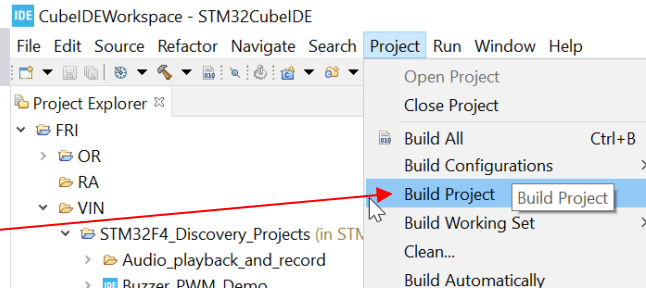
7 – Debug project



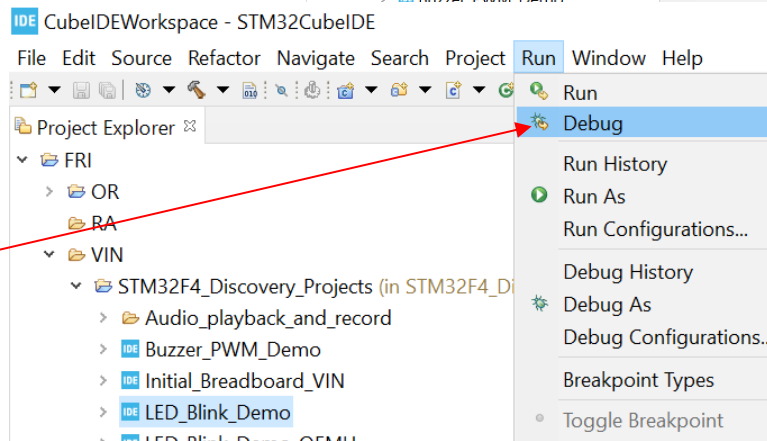
# CubeIDE – Zagon, debug

## Prevajanje, zagon :

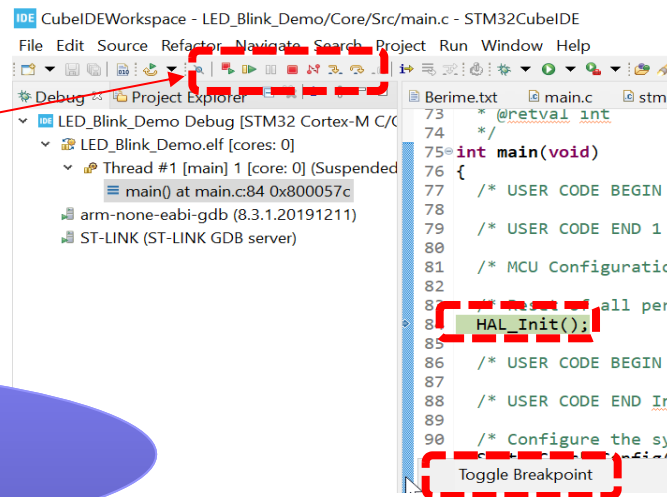
- Project -> Build Project



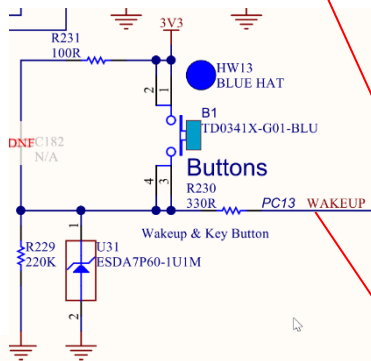
- Run -> Debug



- Step (Into,Over), Breakpoints



Build <-> Debug  
project, ...



### LEDs

U6B  
STM32H750XBH6

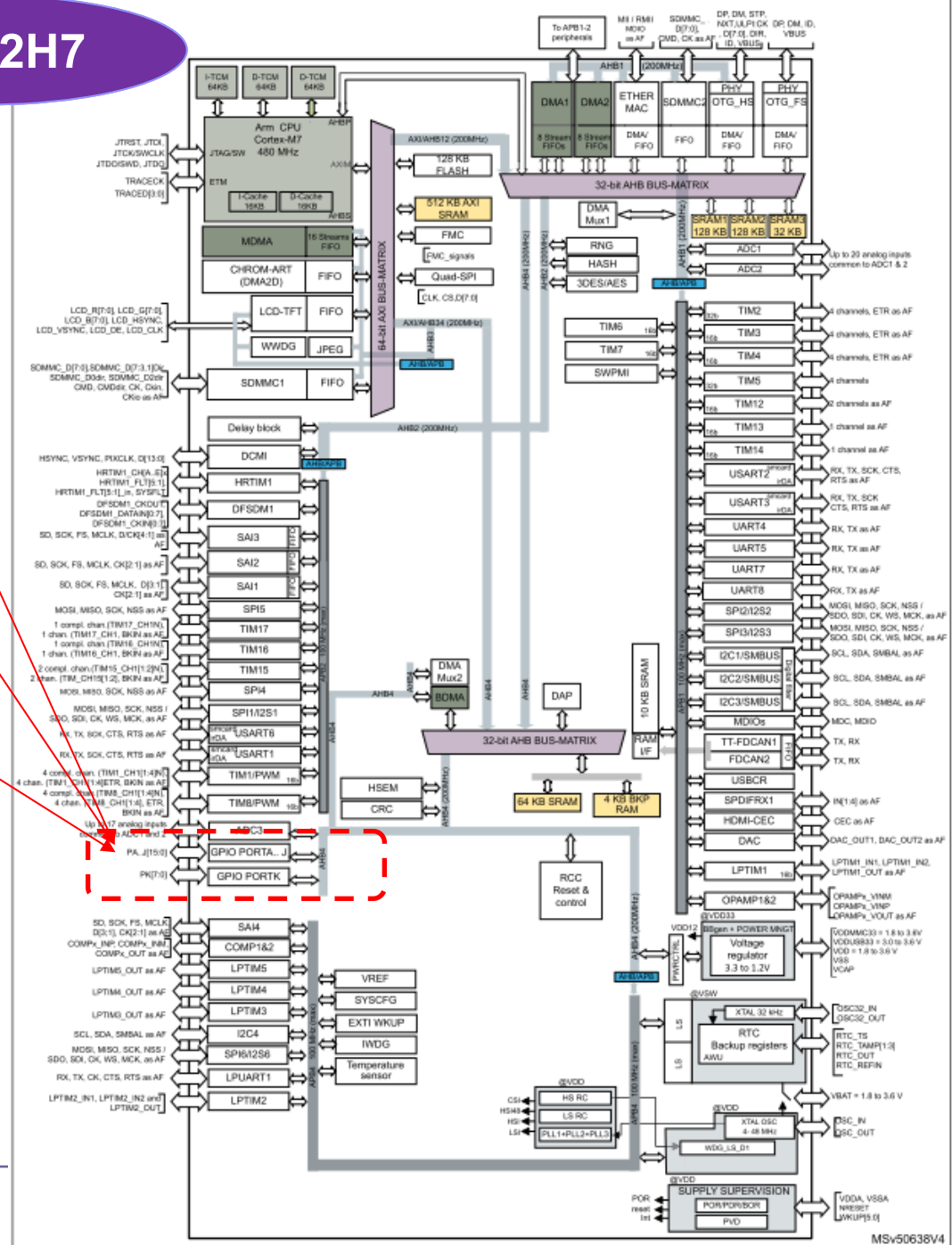
T8	PG0	PI0	A16	LCD G5
U8	PG1	PI1	A15	LCD G6
H16	PG2	PI2	B15	ARD DI2
H15	PG3	PI3	C14	STM0D#8-MOSIs
H14	PG4	PI4	A4	SAI2 MCLKA
G14	PG5	PI5	A3	SAI2 SCKA
G15	PG6	PI6	A2	SAI2 SDA
F16	PG7	PI7	B3	SAI2 FSA
F15	PG8	PI8	E4	ARD D7
A10	PG9	PI9	E2	LCD VSYNC
A9	PG10	PI10	F3	MII RX ER
B9	PG11	PI11	F4	STM0D#18
C9	PG12	PI12	H1	LCD HSYNC
D9	PG13	PI13	H2	LED2
D8	PG14	PI14	H3	LCD CLK
D6	PG15	PI15	P5	LCD R0

PJ0	T6	LCD R2
PJ1	T6	LED1
PJ2	T16	LCD R4

LED: rdeča PJ13, zelena PJ2

VIN – 12 – Predavanja



### HAL - C

UM2217

User manual

Description of STM32H7 HAL and low-layer drivers

#### 35.2.4 IO operation functions

This section contains the following APIs:

- HAL\_GPIO\_ReadPin()
- HAL\_GPIO\_WritePin()
- HAL\_GPIO\_TogglePin()
- HAL\_GPIO\_LockPin()
- HAL\_GPIO\_EXTI\_IRQHandler()
- HAL\_GPIO\_EXTI\_Callback()

```

/* USER CODE BEGIN PV */
#define BUFSIZE 256
char SendBuffer[BUFSIZE];
int Counter;
int KeyState=0;

/* USER CODE END PV */

/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
    HAL_GPIO_TogglePin(GPIOI, GPIO_PIN_13);

    KeyState = HAL_GPIO_ReadPin(GPIOC, GPIO_PIN_13);
    HAL_GPIO_WritePin(GPIOJ, GPIO_PIN_2, KeyState);

    sprintf(SendBuffer, BUFSIZE, "Hello World [%d]: Key:%d\r\n", Counter++, KeyState);
    HAL_UART_Transmit(&huart3, SendBuffer, strlen(SendBuffer), 100);

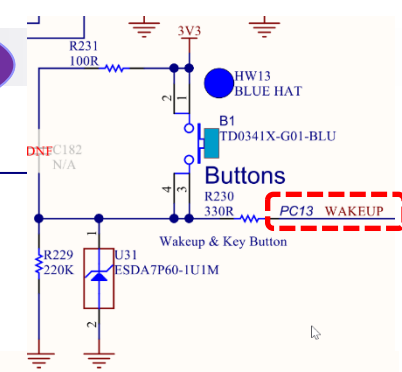
    HAL_Delay(1000);
    /* USER CODE END WHILE */

    /* USER CODE BEGIN 3 */
}
/* USER CODE END 3 */

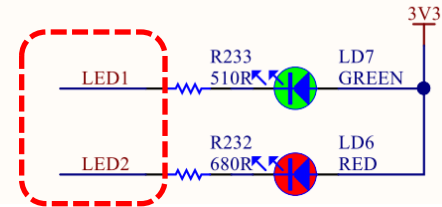
```

## 5 – GPIO

## 6 – USART COM Port



### LEDs



P111	H1	LCD HSYNC
P112	H2	LED2
P113	H3	LCD CLK
P114	P5	LCD R0
P115		

P30	P6	LCD R2
PJ1	T6	LED1
PJ2	T6	LCD R4

## Osnovni projekt CubeIDE – USB Virtual COM Port

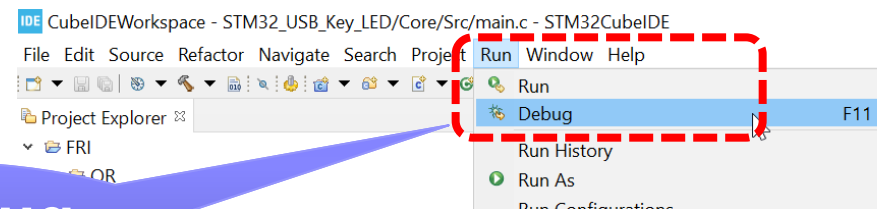
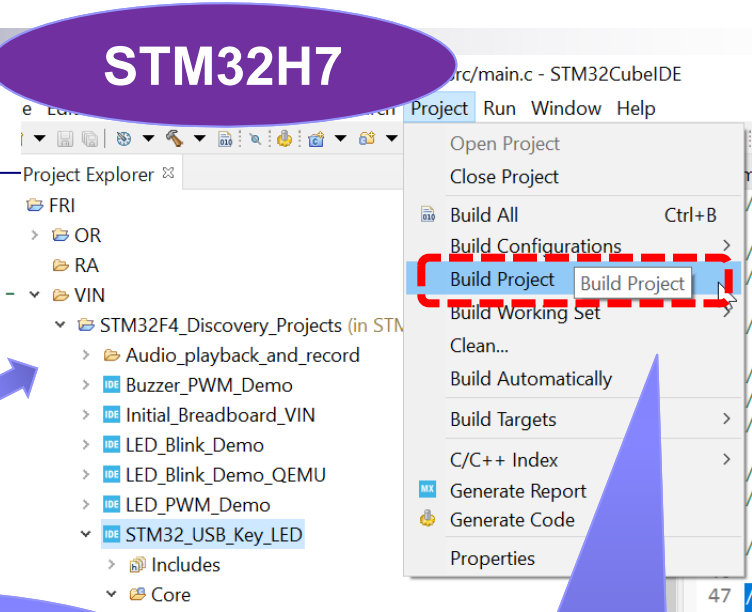
Program : za pošiljanje po USB Virtual COM Port

```
/* Private variables -----  
  
/* USER CODE BEGIN PV */  
#define BUFSIZE 256  
char SendBuffer[BUFSIZE];  
int Counter;  
int KeyState=0;  
  
/* USER CODE END PV */  
  
/* Infinite loop */  
/* USER CODE BEGIN WHILE */  
while (1)  
{  
  
    HAL_GPIO_TogglePin(GPIOI, GPIO_PIN_13);  
  
    KeyState = HAL_GPIO_ReadPin(GPIOI, GPIO_PIN_13);  
    HAL_GPIO_WritePin(GPIOJ, GPIO_PIN_2, KeyState);  
  
    snprintf(SendBuffer, BUFSIZE, "Hello World [%d]: Key:%d\r\n", Counter++, KeyState);  
    HAL_UART_Transmit(&huart3, SendBuffer, strlen(SendBuffer), 100);  
  
    HAL_Delay(1000);  
/* USER CODE END WHILE */  
  
/* USER CODE BEGIN 3 */  
}  
/* USER CODE END 3 */
```

7 – Delay

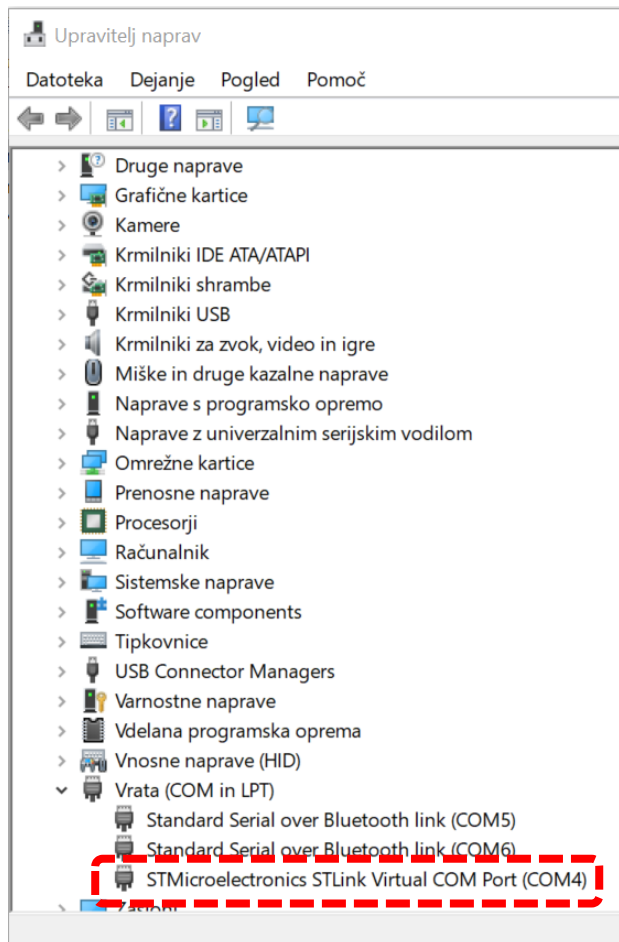
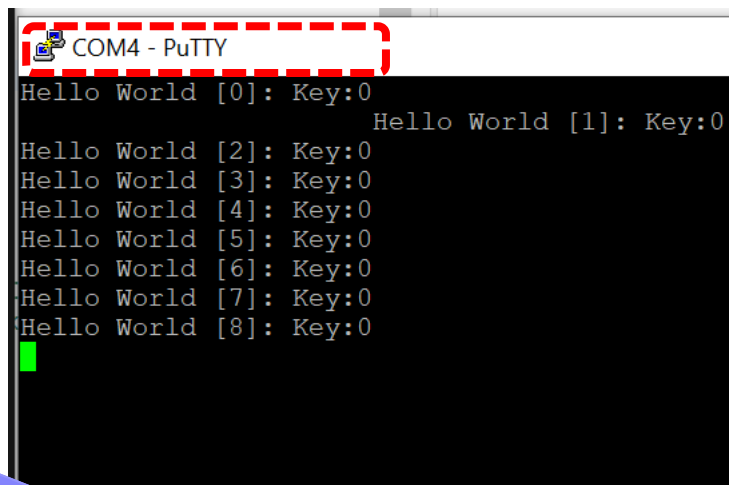
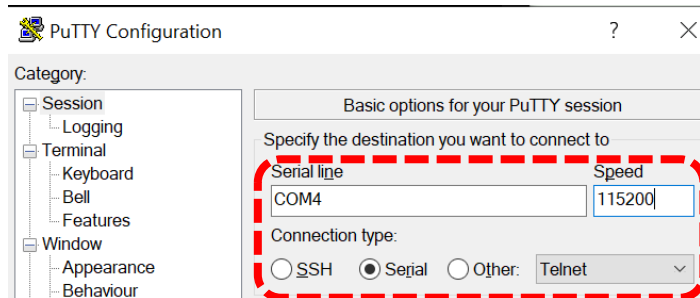
8 – Build project

9 – Debug project



## Osnovni projekt CubeIDE – USB Virtual COM Port (USART3 na STM strani)

Program : sprejem na PC strani (povezava z Micro-USB kablom)

<https://the.earth.li/~sgtatham/putty/latest/w64/putty.exe>

10 – Test project

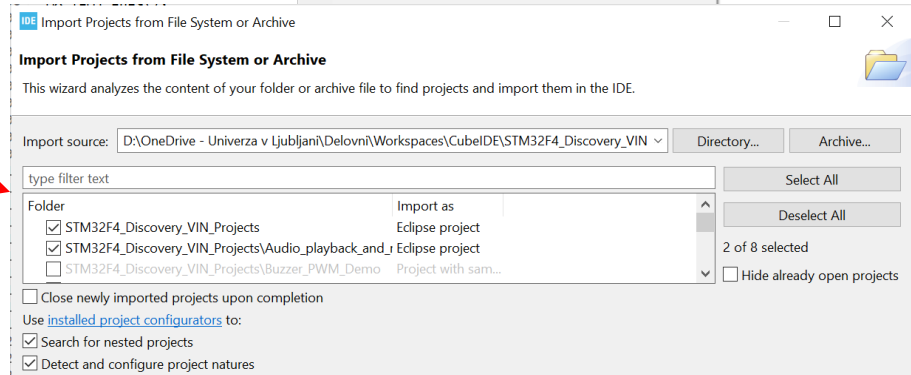
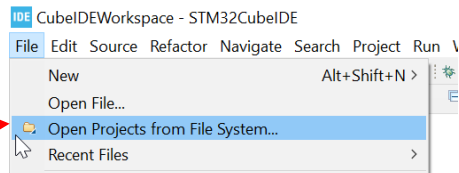
# 12.b VIN projekt in SensorTile.box

- Praktična naloga - VIN Projekt
  - Razvojne plošče
  - Viri (gradiva, posnetki, primeri, ...)
  - Osnovna projekta v CubeIDE:
    - CubeMX (HAL knjižnica, BSP) – STM32H7, STM32F4
      - CubeMX – osnovni projekt (GPIO – tipka, LED diode, USART)
      - BSP – osnovni projekt (Touch, LCD)
- SensorTile.box (kompaktna razvojna platforma)
  - Edge Computing platforma
- STM AI ekosistem in Orange Data Mining

# CubeIDE: delo na STM32 sistemih

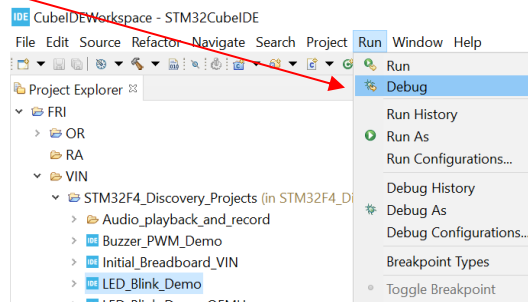
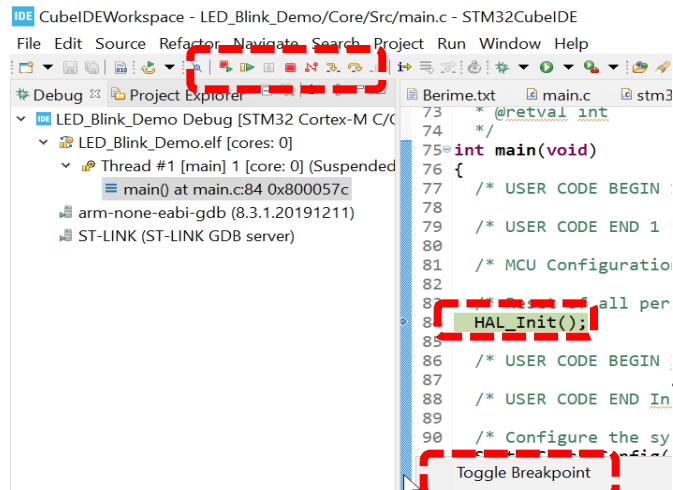
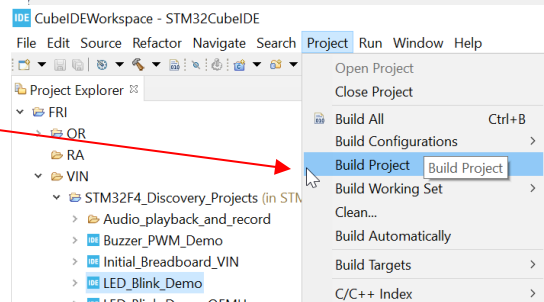
## Uvoz obstoječega projekta (npr. BSP... iz Github)

- Open projects from File System
- Select project(s)



## Prevajanje, zagon :

- Project -> Build Project
- Run -> Debug
- Step (Into,Over), Breakpoints



## LAPSyLAB/STM32H7\_Discovery\_VIN\_Projects

Z naslova <[https://github.com/LAPSyLAB/STM32H7\\_Discovery\\_VIN\\_Projects](https://github.com/LAPSyLAB/STM32H7_Discovery_VIN_Projects)>

<a href="#">.settings</a>	<a href="#">Breadboard project added (initial preparation)</a>	last year
<a href="#">STM32H750-DK BSP Touch Demo</a>	<a href="#">BSP Touch Demo project added (Basic starting BSP project)</a>	2 weeks ago
<a href="#">STM32H750B-DK Breadboard VIN</a>	<a href="#">Update 2024 1.st</a>	2 months ago
<a href="#">STM32H750B-DK Buzzer PWM Demo</a>	<a href="#">Update 2024 1.st</a>	2 months ago
<a href="#">STM32H750B-DK C CAN IEX Module Base</a>	<a href="#">Minor update</a>	4 days ago
<a href="#">STM32H750B-DK I2C Basic Demo</a>	<a href="#">Update 2024 1.st</a>	2 months ago
<a href="#">STM32H750B-DK I2C Touch Demo</a>	<a href="#">Update 2024 1.st</a>	2 months ago
<a href="#">STM32H750B-DK VIN Basic</a>	<a href="#">Update 2024 1.st</a>	2 months ago
<a href="#">.gitignore</a>	<a href="#">Initial commit</a>	last year
<a href="#">.project</a>	<a href="#">Breadboard project added (initial preparation)</a>	last year
<a href="#">README.md</a>	<a href="#">Initial commit</a>	last year

## LAPSyLAB/STM32H7\_Discovery\_VIN\_Projects

Z naslova [<https://github.com/LAPSyLAB/STM32H7\\_Discovery\\_VIN\\_Projects>](https://github.com/LAPSyLAB/STM32H7_Discovery_VIN_Projects)

### STM32H750-DK BSP Touch Demo

#### Vključuje HAL knjižnico in podporno kodo (BSP) za STM32H7

- BSP ... Board Support Package
- - Ni generiran s CubeMX, vse spreminjamo ročno v kodi
- + delujejo zaslون, dotiki, ostale naprave

### STM32H750B-DK VIN Basic

#### Vključuje HAL knjižnico in je generiran s CubeMX

- + generiran s CubeMX, lahko spreminjamo konfiguracije
- - ne delujejo zaslون, dotiki, ostale naprave
  - Lahko pa se minimalna koda doda (nastavitve so večinoma že prisotni)

IDE STM32H750-DK\_BSP\_Touch\_Demo

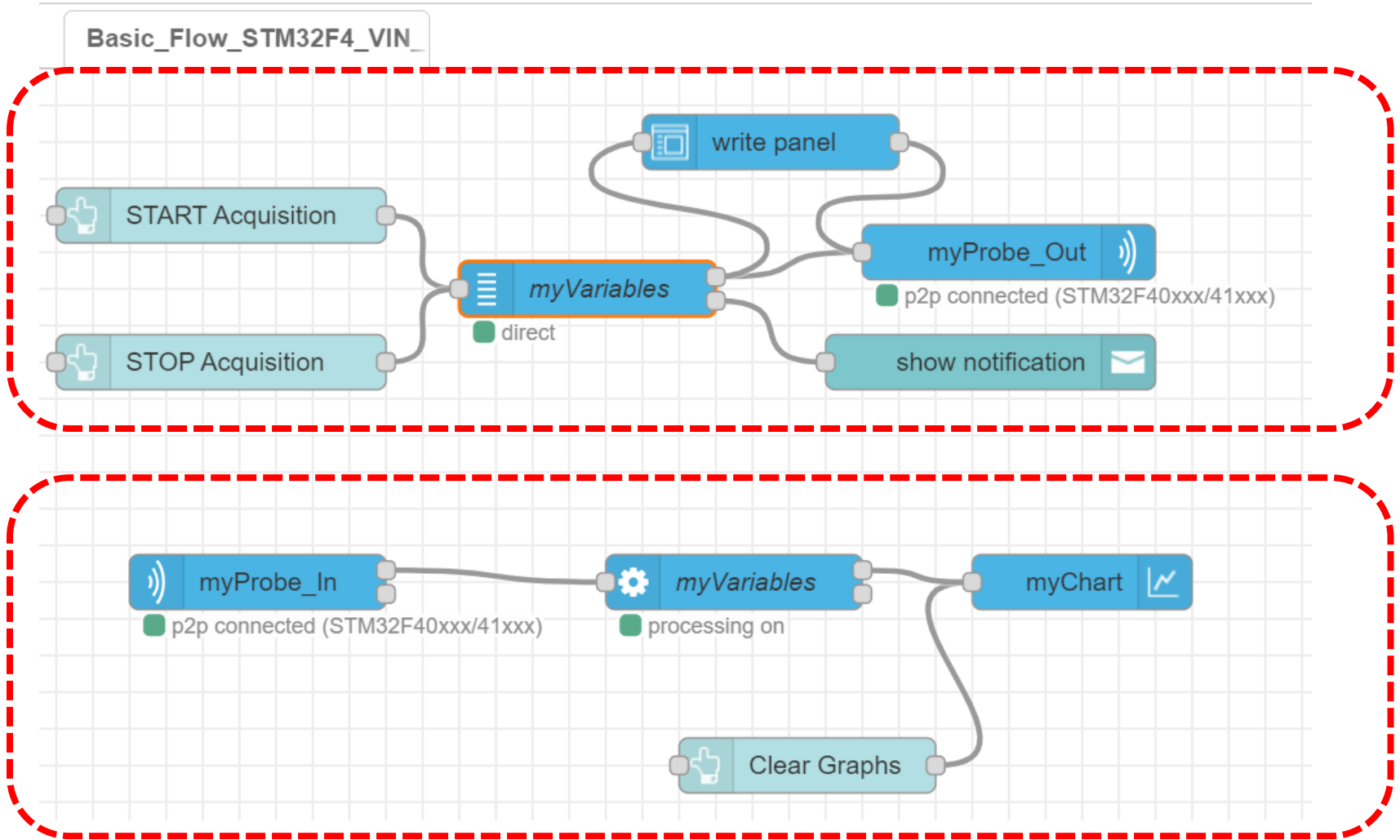
```

> Binaries
> Includes
v Core
  > Components
  v Inc
    > ft5336_conf.h
    > main.h
    > mt25tl01g_conf.h
    > mt48lc4m32b2_conf.h
    > stm32_lcd.h
    > stm32h750b_discovery_bus.h
    > stm32h750b_discovery_conf.h
    > stm32h750b_discovery_errno.h
    > stm32h750b_discovery_lcd.h
    > stm32h750b_discovery_qspi.h
    > stm32h750b_discovery_sdram.h
    > stm32h750b_discovery_ts.h
    > stm32h750b_discovery.h
    > stm32h7xx_hal_conf.h
    > stm32h7xx_it.h
  > Src
    > main.c
    > stm32_lcd.c
    > stm32h750b_discovery_bus.c
    > stm32h750b_discovery_lcd.c
    > stm32h750b_discovery_qspi.c
    > stm32h750b_discovery_sdram.c
    > stm32h750b_discovery_ts.c
    > stm32h750b_discovery.c
    > stm32h7xx_hal_msp.c
    > stm32h7xx_it.c
    > syscalls.c
    > systemem.c
    > system_stm32h7xx.c
    > touchscreen.c
  
```

```

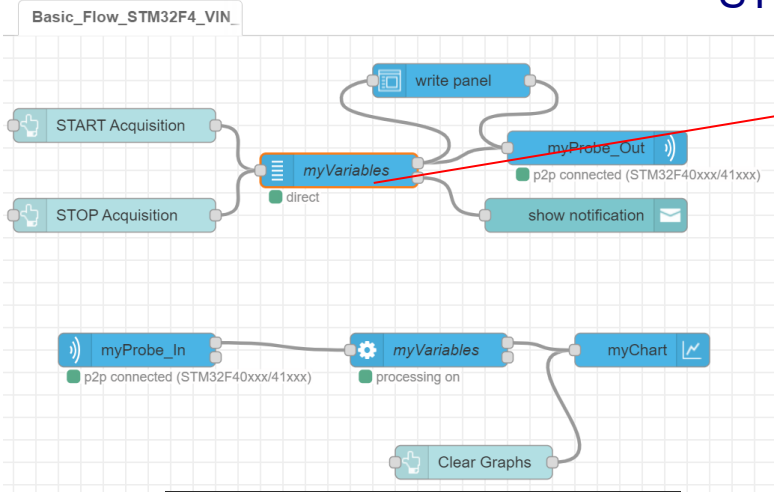
v IDE STM32H750B-DK_VIN_Basic
  > Binaries
  > Includes
  v Core
    > Inc
      > main.h
      > stm32h7xx_hal_conf.h
      > stm32h7xx_it.h
    > Src
      > main.c
      > stm32h7xx_hal_msp.c
      > stm32h7xx_it.c
      > syscalls.c
      > systemem.c
      > system_stm32h7xx.c
  
```

# STM32CubeMonitor



<https://wiki.stmicroelectronics.cn/stm32mcu/wiki/Category:STM32CubeMonitor>

# STM32CubeMonitor



Edit variables node > **Edit exe-config node**

**Delete** Cancel **Update**

**Properties**

Name: MyVariables

Folder: D:\Delovni\CubeIDE\Sluzba\STM32F4\_Discovery\_VIN\_Prc

File: STM32F4\_GPIO\_PWM\_SPI\_I2C\_C\_Demo.elf

Expand Variable List

**Variable List**

Select	Name	Start Address	Type
<input type="checkbox"/>	__sbrk_heap_end	0x200003d0	Unsigned 32-bit
<input checked="" type="checkbox"/>	AccelX	0x2000036f	Signed 8-bit
<input checked="" type="checkbox"/>	AccelY	0x20000370	Signed 8-bit
<input checked="" type="checkbox"/>	AccelZ	0x20000371	Signed 8-bit
<input type="checkbox"/>	AHBPrescTable[0]	0x0800b8cc	Unsigned 8-bit
<input checked="" type="checkbox"/>	AnalogValue1	0x20000374	Signed 32-bit
<input type="checkbox"/>	APBPrescTable[0]	0x0800b8dc	Unsigned 8-bit
<input type="checkbox"/>	CDCCmdEpAdd	0x20000099	Unsigned 8-bit
<input type="checkbox"/>	CDCInEpAdd	0x20000097	Unsigned 8-bit
<input type="checkbox"/>	CDCOutEpAdd	0x20000098	Unsigned 8-bit
<input checked="" type="checkbox"/>	ChipID	0x20000360	Unsigned 8-bit
<input type="checkbox"/>	Counter	0x20000350	Signed 32-bit
<input checked="" type="checkbox"/>	Duty	0x20000358	Signed 32-bit
<input type="checkbox"/>	FS_Drvr_CatConfiguration	0x20000004	Unsigned 32-bit

**DEPLOY** **DASHBOARD**



## ■ Workflow s Clickboard

- Vrsta komunikacije (I2C, SPI, UART)
- Protokol komunikacije (Podatk. Listina, knjižnica) ...
- Od enostavnejših do kompleksnejših opravil

# 12.b VIN projekt in SensorTile.box

## ■ Praktična naloga - VIN Projekt

- Razvojne plošče
- Viri (gradiva, posnetki, primeri, ...)
- Osnovna projekta v CubeIDE:
  - CubeMX (HAL knjižnica, BSP) – STM32H7, STM32F4
    - CubeMX – osnovni projekt (GPIO – tipka, LED diode, USART)
    - BSP – osnovni projekt (Touch, LCD)

## ■ SensorTile.box (kompaktna razvojna platforma)

- Edge Computing platforma

## ■ STM AI ekosistem in Orange Data Mining

# 12.b VIN projekt in SensorTile.box

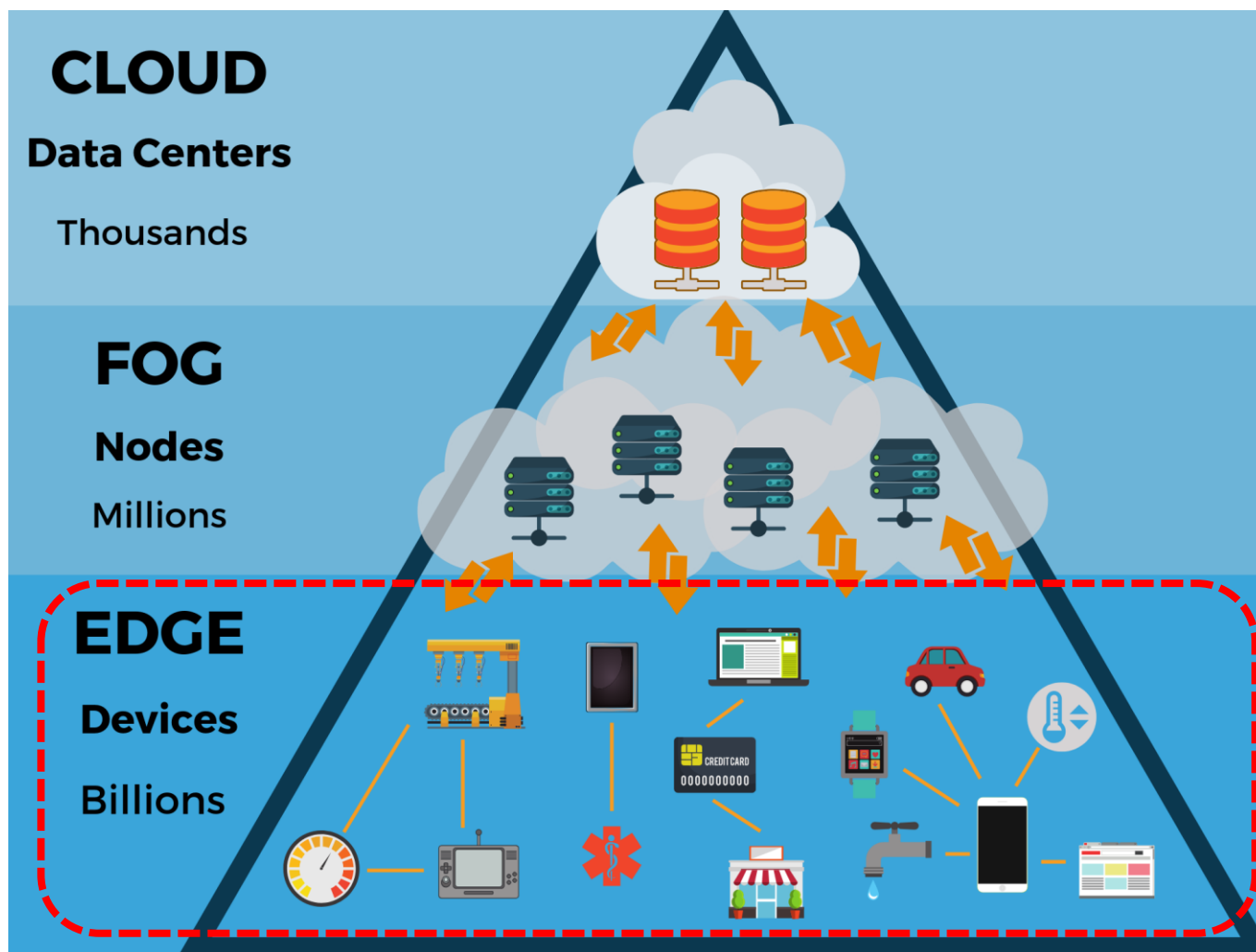
## ■ Praktična naloga - VIN Projekt

- Razvojne plošče
- Viri (gradiva, posnetki, primeri, ...)
- Osnovna projekta v CubeIDE:
  - CubeMX (HAL knjižnica, BSP) – STM32H7, STM32F4
    - CubeMX – osnovni projekt (GPIO – tipka, LED diode, USART)
    - BSP – osnovni projekt (Touch, LCD)

## ■ Edge Computing

- SensorTile.box (kompaktna Edge AI razvojna platforma)
- STM AI ekosistem in Orange Data Mining

# Edge computing



# Cloud AI vs. Edge AI

## Oblak (Cloud AI)

- Visoka latenca (round-trip)
- Zahteva stalno omrežje
- Visoka poraba energije v podatkovnih centrih
- Zasebnost: podatki zapuščajo napravo
- Ne deluje pri izpadu omrežja

## Edge AI (na napravi)

- Nizka latenca – odziv v realnem času
- Deluje brez omrežja
- Manjša poraba energije
- Podatki ostanejo na napravi (zasebnost)
- Manjši promet v omrežju

**ABI Research: trg Edge AI MCU bo do leta 2030 dosegel ~1,8 milijarde enot letno**

# Edge computing

## Smart system challenges Moving to edge computing

### CLOUD COMPUTING

### EDGE COMPUTING

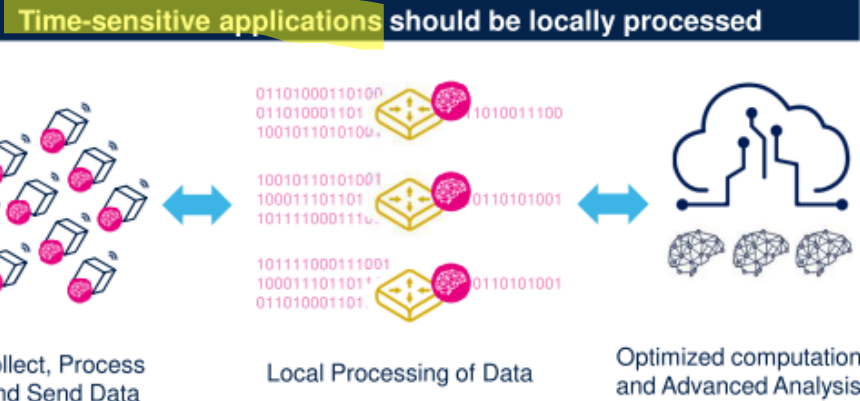
Collect and send data

Protocol translation and device management

Big Data and heavy computation

**Time-sensitive applications should be locally processed**

**Time-sensitive applications are limited by remote cloud**



Mission-critical functions

Bandwidth limitations

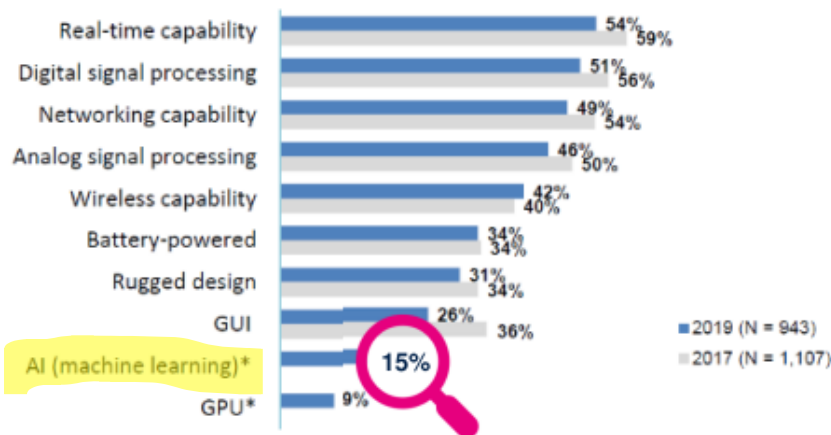
Privacy and security considerations

Power consumption



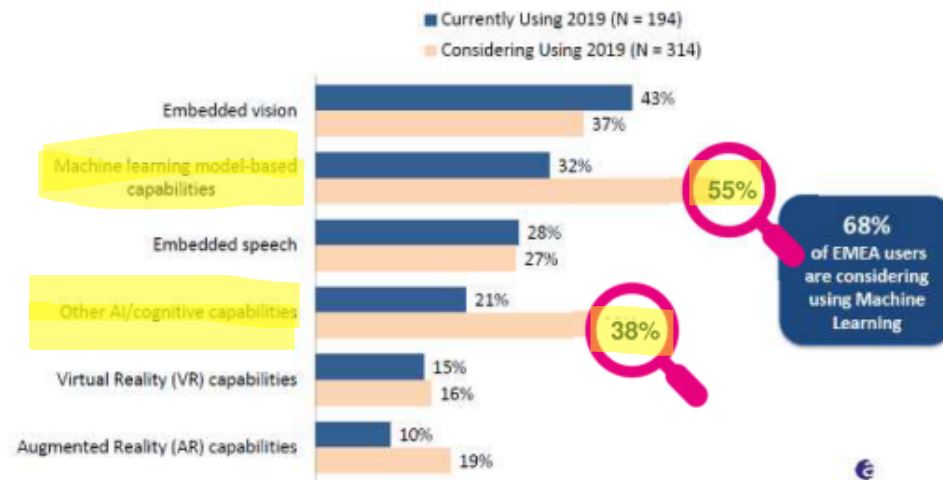
## AI is moving to the edge

### Capabilities included in a project



\*AI and GPU were added in 2019.

### Advanced technology in a project



68% of EMEA users are considering using Machine Learning

- 15% of embedded projects already include AI in 2019
- Pervasion of Machine Learning and other AI capabilities

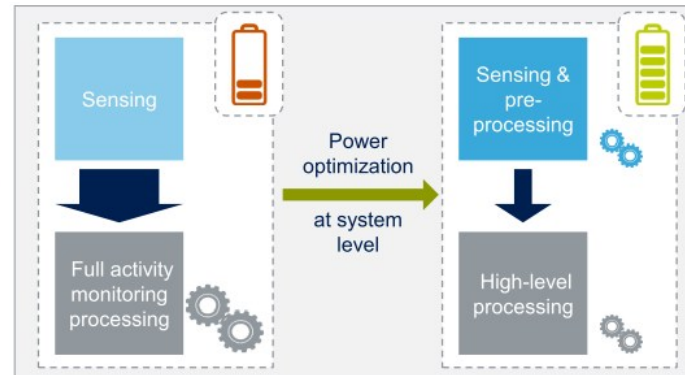
# Edge computing – moduli, tipala

## BHI260AP

Ultra-low power, high performance, **self-learning AI** smart sensor with integrated accelerometer and gyroscope



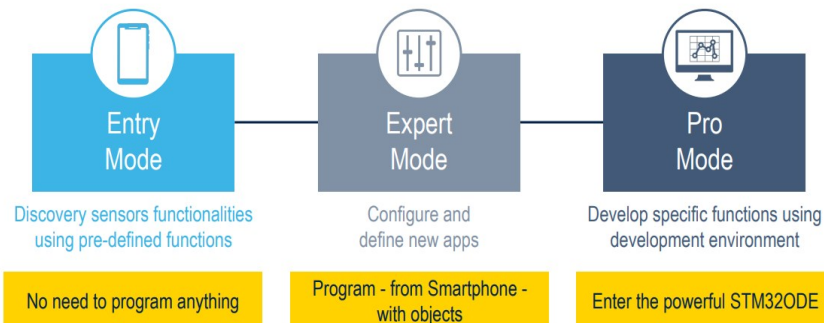
## LSM6DSOX Unique Performance



# STEVAL-MKSBOX1V1 SensorTile.box razvojni sistem

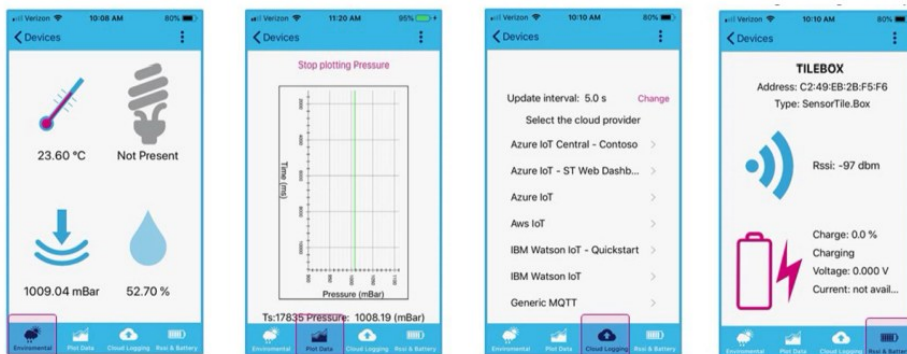
The IoT made easy

SensorTile.box has 3 operational modes



## KAJ VSE OMOGOČA APLIKACIJA?

V realnem času s pomočjo senzorjev zaznava stanje v okolju, risanje grafov na podlagi podatkov, shranjevanje podatkov v oblak - cloud logging.



## VGRAJENE APLIKACIJE

Primeri vgrajenih aplikacij, dostopnih v Entry Mode načinu aplikacije STE BLE Sensor:

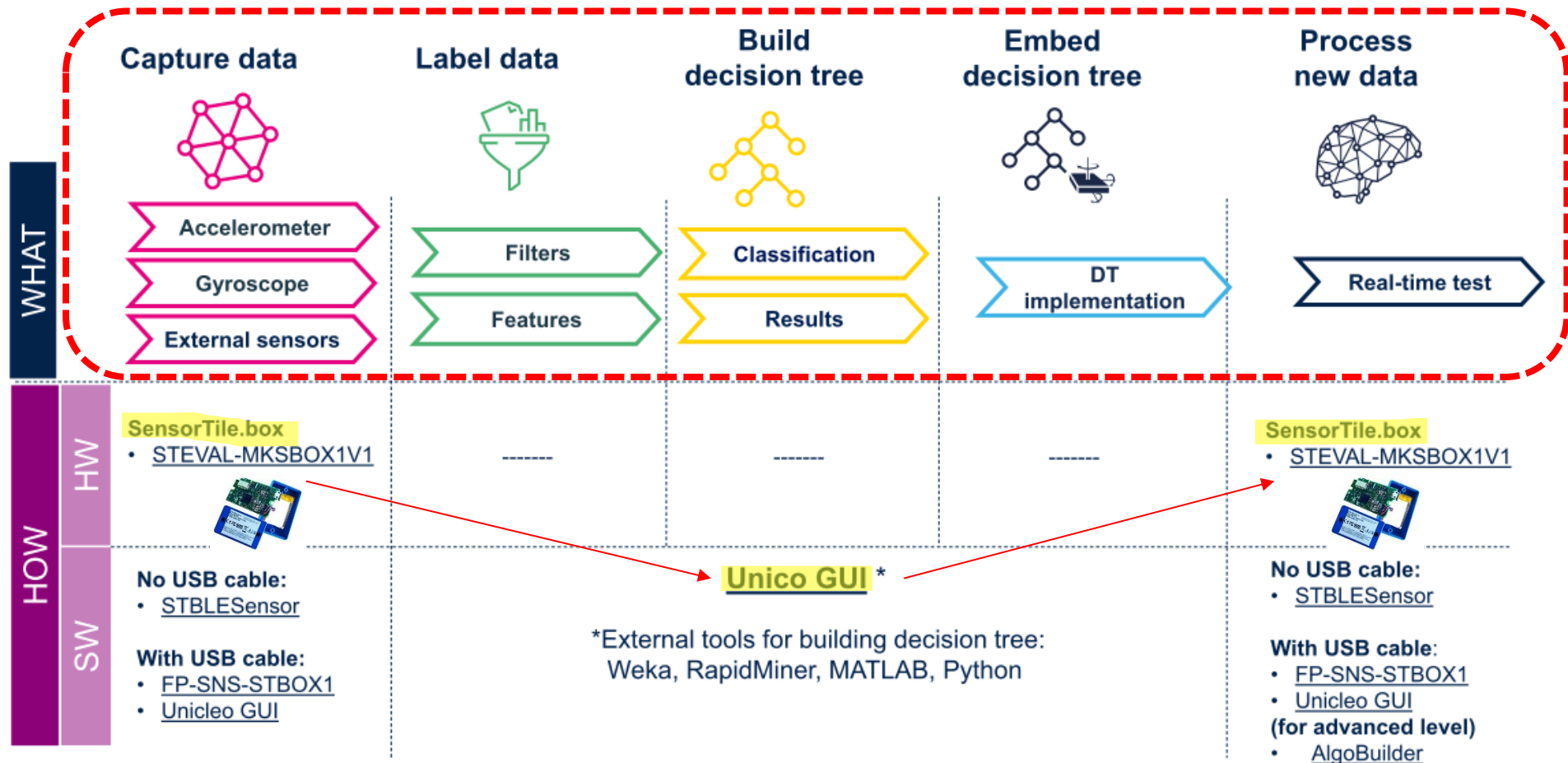
- Preprosta aplikacija za štetje korakov s pomočjo merilnika pospeška
- Zaznavanje otroškega joka
  - zaznavanje otroškega joka preko mikrofona, prižig LED diode/opozorilo na aplikaciji, ko je jok zaznan
- Barometriška aplikacija
  - omogoča dodatno ponastavljanje senzorjev za temperaturo, tlak in vlago, prejete meritve prikaže grafično v obliki
- Sledenje prevažanim dobrinam, stanje v vozilu
  - s primernimi tipali (npr. merilnik vlage) merimo pogoje, katerim bi bili potencialno izpostavljeni izdelki, prevažani v nekem vozilu
- Vibration monitoring
  - določimo neko sprejemljivo meritev tresljajev, ki jih zaznamo z merilnikom pospeška - o morebitnih odstopanjih obvestimo uporabnika in zabeležimo dogodek
- Compass and inclinometer
  - beleženje sprememb v orientaciji SensorTile.box-a tekom časa, grafični prikaz meritev (npr. spremembe v smeri neba, naklon)



<https://www.st.com/en/evaluation-tools/steval-mksbox1v1.html>

# Edge computing – moduli, tipala

## LSM6DSOX – SensorTile.box

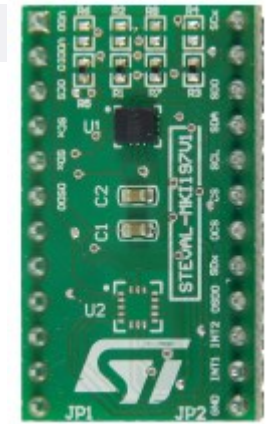
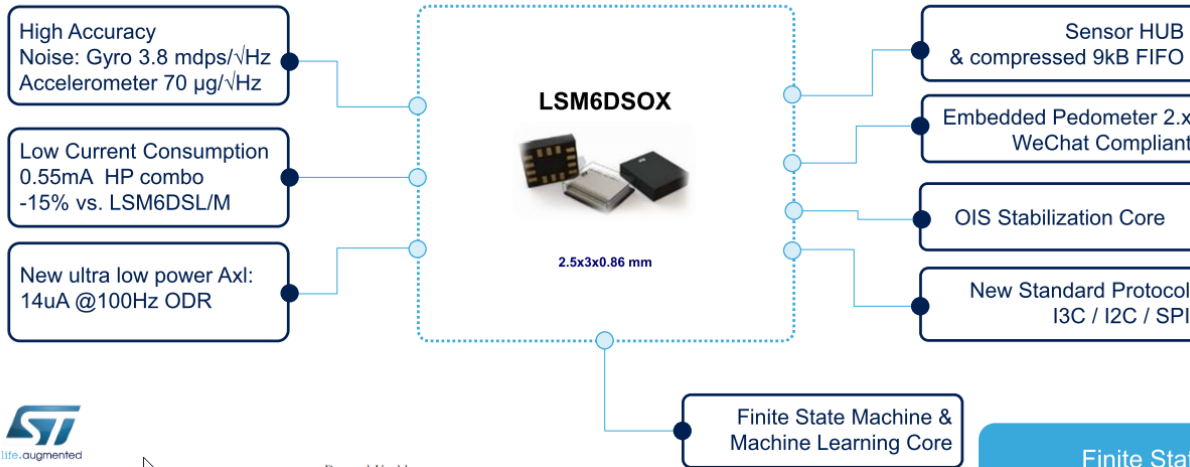


# Edge computing – moduli, tipala



## LSM6DSOX Unique Performance

Improved Accuracy, Optimized System Power

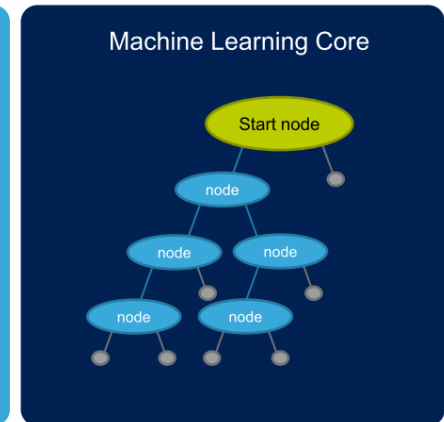
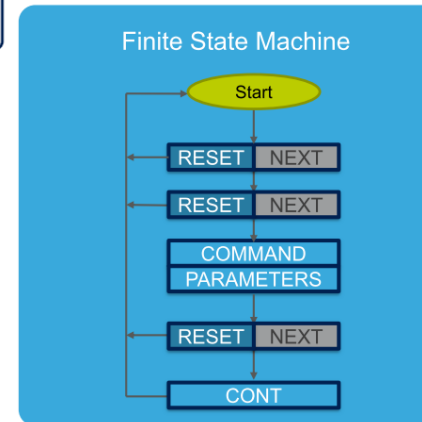
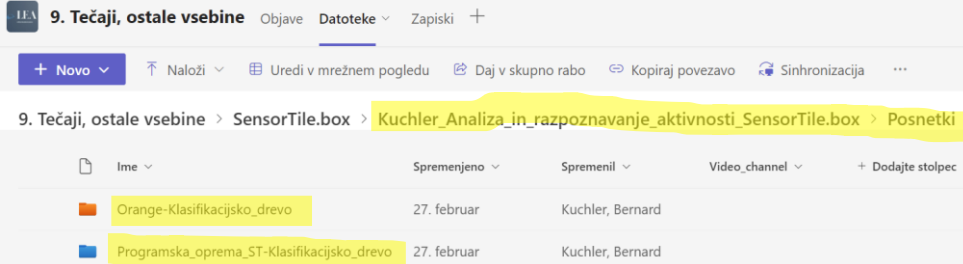


Jan Renar  
Zaznavanje človeških aktivnosti s  
tipali na razvojni plošči **Sensortile.box**  
DIPLOMSKO DELO



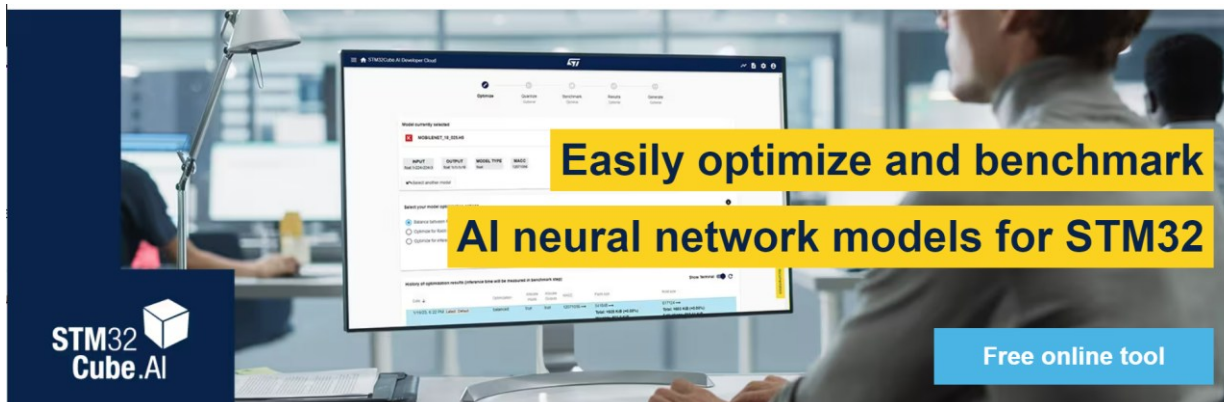
Bernard Kuchler  
Uporaba modelov strojnega učenja v  
vgrajenih sistemih

DIPLOMSKO DELO



FSM & MLC allows sensors to process data with reduced help of a host MCU

# Edge computing – Optimizacija AI modelov

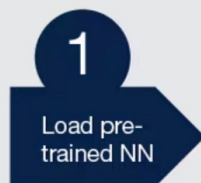


**Easily optimize and benchmark  
AI neural network models for STM32**

STM32  
Cube.AI

Free online tool

Just login to create, optimize and benchmark your neural network!

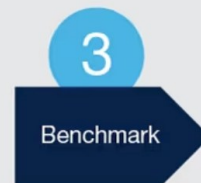


VIN projekt - VP4: STM32-Edge...

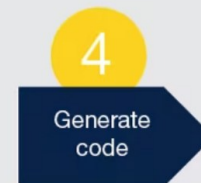
Upload your own model or select one from STM32 model zoo



Get metrics on complexity and memory footprint



Measure inference time on real STM32 boards remotely



Download the AI code for your STM32

<https://stm32ai-cs.st.com/home>

# Edge computing – TensorFlow Lite in ARM Cortex-M4

## MAKING MACHINE LEARNING ARDUINO COMPATIBLE

A GAMING HANDHELD THAT RUNS  
NEURAL NETWORKS

*A BIT OF FUN: After she created an Arduino-compatible version of TensorFlow Lite, the author adapted a voice-recognition demo so that pressing a button and speaking into a microphone attached to a SAMD51-based PyGamer would play back different animations.*







<https://spectrum.ieee.org/machine-learning-thats-light-enough-for-an-arduino>



**A BIT OF FUN:** After she created an Arduino-compatible version of TensorFlow Lite, the author adapted a voice-recognition demo so that pressing a button and speaking into a microphone attached to a SAMD51-based PyGamer would play back different animations.



## Embedded solutions with edge processing for wearables

Configuration example	Description	Where?
 <b>Activity recognition for wrist</b>	Stationary / other, walking / fast walking, jogging / running	Accelerometer data processed by MLC
 <b>Gym activity recognition</b>	Bicep curls, lateral rises, squats	Accelerometer data processed by MLC
 <b>Gestures detection</b>	Flip-up/down, 4D, glance, pick-up, phone-to-ear, jiggle / shake, wrist navigation, wrist-tilt	Accelerometer + Gyroscope data processed by FSM (or MLC)
 <b>Free fall &amp; shock height estimation</b>	Detect free-fall & shock events with free fall height estimation	Accelerometer data processed by FSM
 <b>Shock intensity estimation</b>	Detect shock events with intensity estimation	Accelerometer data processed by FSM & MLC
 <b>Pedometer</b>	Step detection, step counter and significant motion detection	Accelerometer pedometer
 <b>Pose recognition</b>	Detect 14 classes	Accelerometer data processed by MLC



# STM – Transforming Edge AI: The power of neural processing units in modern microcontrollers

ST announces the first member of its **Neural-ART Accelerator™** series: a purpose-designed NPU with highly parallelized hardware co-processor that's available for the main embedded application to assign AI workloads.



Figure 3: Neural-ART Accelerator architecture overview

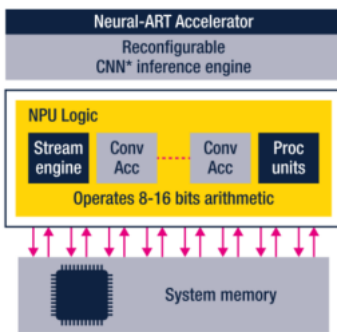


Figure 1: Power efficiency of various hardware architectures

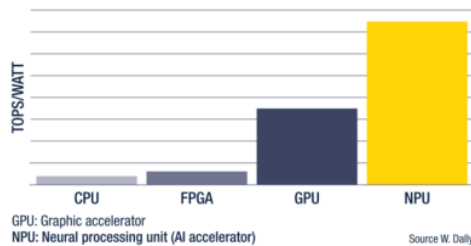


Figure 4: Edge AI software ecosystem

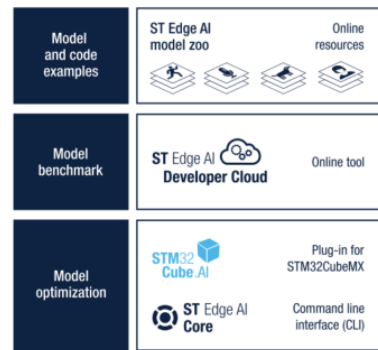


Table 1: Results measured on Neural-ART Accelerator Gen1, with 4 convolution array at 1 GHz

Model	CPU-bound inferring on Cortex-M55 @ 400 MHz		Accelerated inferring on Neural-ART Accelerator @ 1 GHz		Improvement with acceleration
	Time (ms)	fps	Time (ms)	fps	
MobileNet v1 <sup>1</sup>	2244	0.45	19.4	51.54	x116
MobileNet v2 <sup>2</sup>	1385	0.72	21.1	47.45	x66
Tiny Yolo v2 <sup>3</sup>	3895	0.26	30.6	32.71	x127
Yolo v8n 256 <sup>4</sup>	1821	0.55	31	32.26	x59
Yamnet 1024 <sup>5</sup>	252	3.97	9.8	101.7	X26

Note: 1 **Image Classification** - Quantized int8, input resolution 224x224x3, trained on ImageNet dataset. Model footprint: 4.45 MB weights, 1.53 MB activations  
 2 **Image Classification** - Quantized int8, input resolution 224x224x3, trained on ImageNet dataset. Model footprint: 4.14 MB weights, 2.08 MB activations  
 3 **Object Detection** - Quantized int8, input resolution 224x224x3, trained on COCO dataset. Model footprint: 10.55 MB weights, 0.38 MB activations  
 4 **Object Detection** - Quantized int8, input resolution 256x256x3, trained on COCO dataset. Model footprint: 3.05 MB weights, 1.6 MB activations  
 5 **Audio Event Classification** - Quantized int8, input resolution 64x96, trained on AudioSet dataset. Model footprint: 3.4 MB weights, 0.14 MB activations

Case Study 1: People detection for consumer tracking applications



People detection and tracking  
Yolo v8 320x320  
Neural-ART with 4 Convolution Array at 1 GHz = 26 fps

Screen capture of the actual demo board screen.

[Whitepaper-transforming-edge-ai-with-npus-in-microcontrollers](#)

# NPU – Neural Processing Unit

## Zakaj standardni MCU (CPU) ni dovolj za AI inferenco?

Nevronske mreže zahtevajo množico operacij akumulacije in množenja (MAC) z velikim dostopom do pomnilnika – klasična sekvenčna arhitektura (fetch–decode–execute) tega ne more izvesti učinkovito.

Lastnost	CPU	GPU	NPU
Primarna vloga	Splošna obdelava	Grafika, paralela	Pospeševanje NN
Arhitektura	Malo jeder, visoka ura	Mnogo malih jeder, SIMD	Specializirana jedra za NN
Učinkovitost energije	Zmerna	Zmerna–visoka	Visoka
Primerna za	Splošno računanje	Grafika, ML treniranje	Edge AI, IoT, inference

**ST Neural-ART Accelerator™ – ST-ov NPU integriran v STM32 mikrokrmilnike**

# ST Neural-ART Accelerator™

*STMicroelectronics – prvi NPU v seriji Neural-ART Accelerator™ integriran v STM32 mikrokrmilnike*

## Arhitektura NPU

- Večkratni specializirani HW pospeševalniki
- Rekonfigurabilni dataflow stream engine
- Konvolucijski pospeševalniki (Conv Acc)
- Fiksna vejica: 8-bitna ali 16-bitna aritmetika
- Podpira 130+ operatorjev (ONNX, TF, Keras)

## Prednosti in orodja

- STM32Cube.AI – konverzija modelov v C kodo
- ST Edge AI Developer Cloud – online benchmarking
- ST Edge AI Model Zoo – predtrenirani modeli
- ST Edge AI Suite – celovit razvijalski paket
- Podpira TensorFlow, Keras, ONNX, PyTorch, MATLAB

# Benchmark: Neural-ART vs. Cortex-M55

Primerjava inference časa – STM32 z Neural-ART Acceleratorjem vs. Cortex-M55 @ 400 MHz

Model	CPU: čas (ms)	CPU: fps	NPU: čas (ms)	NPU: fps	Izboljšanje
MobileNet v1	2244	0.45	19.4	51.5	<b>×116</b>
MobileNet v2	1385	0.72	21.1	47.5	<b>×66</b>
Tiny Yolo v2	3895	0.26	30.6	32.7	<b>×127</b>
Yolo v8n	1821	0.55	31	32.3	<b>×59</b>
YAMNet (zvok)	252	3.97	9.8	101.7	<b>×26</b>

**Primer 1 – People detection (Yolo v8, 320×320): 26 fps v realnem času na STM32N6**

Primer 2 – Smart city (TinyYolo v2, 416×416): 18 fps – klasifikacija vozil in pešcev

Vir: ST Microelectronics – Transforming Edge AI with NPUs in Microcontrollers (dec. 2024)

# 12.b VIN projekt in SensorTile.box

## ■ Praktična naloga - VIN Projekt

- Razvojne plošče
- Viri (gradiva, posnetki, primeri, ...)
- Osnovna projekta v CubeIDE:
  - CubeMX (HAL knjižnica, BSP) – STM32H7, STM32F4
    - CubeMX – osnovni projekt (GPIO – tipka, LED diode, USART)
    - BSP – osnovni projekt (Touch, LCD)

## ■ Edge Computing

### ■ SensorTile.box (kompaktna Edge AI razvojna platforma)

## ■ STM AI ekosistem in Orange Data Mining

# STEVAL-MKSBOX1V1 SensorTile.box razvojni sistem

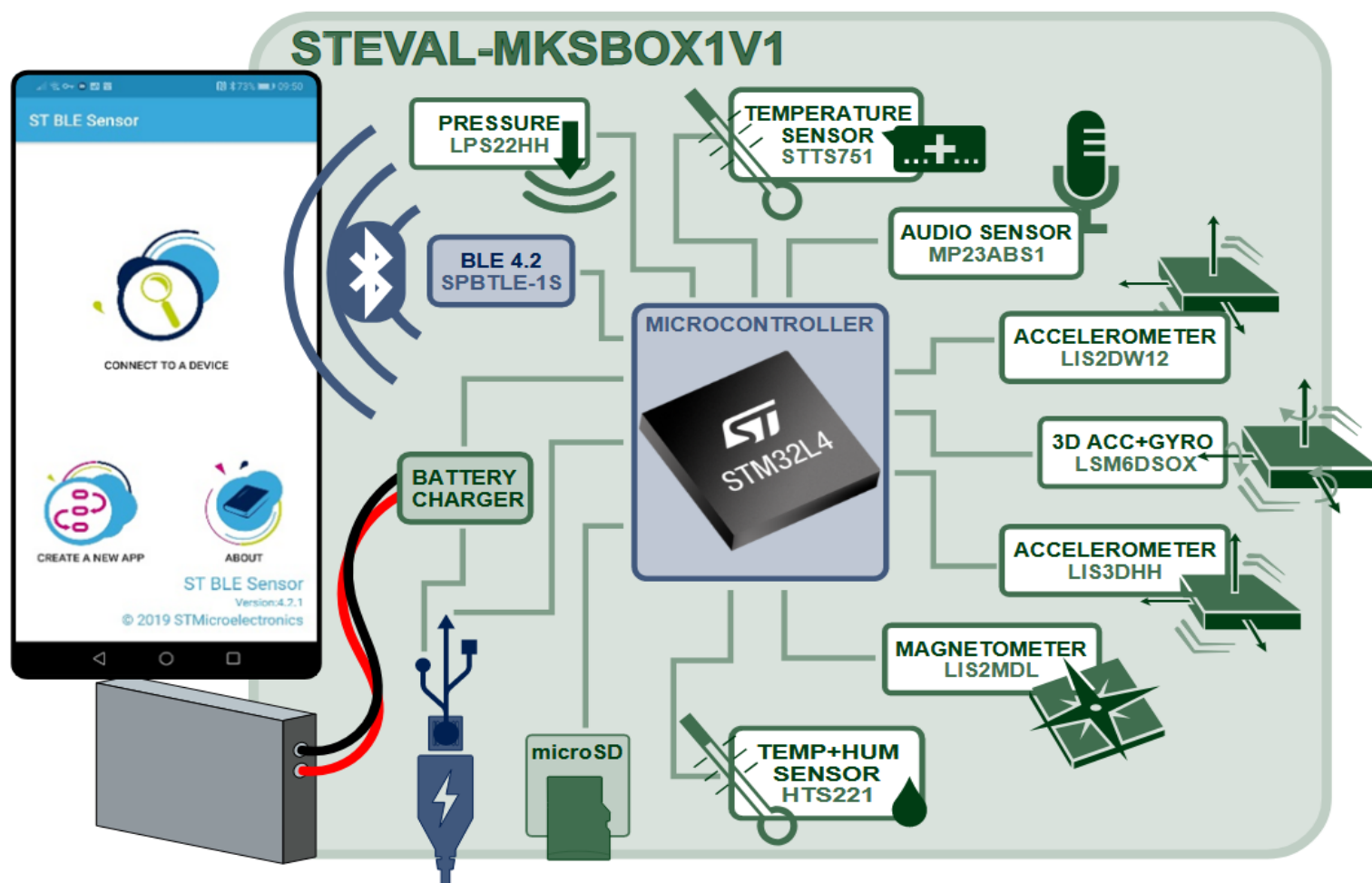
## All features

- Easy-to-use app with immediate functionality for the following motion and environmental sensor applications:
  - Pedometer optimized for belt positioning
  - Baby crying detection with Cloud AI learning
  - Barometer / environmental monitoring
  - Vehicle / goods tracking
  - Vibration monitoring
  - Compass and inclinometer
  - Sensor data logger
- Expert Mode with additional sensor app parameter settings
- Compact board with the following high precision sensors:
  - Digital temperature sensor (STTS751)
  - 6-axis inertial measurement unit (LSM6DSOX)
  - 3-axis accelerometers (LIS2DW12 and LIS3DHH)
  - 3-axis magnetometer (LIS2MDL)
  - Altimeter / pressure sensor (LPS22HH)
  - Microphone / audio sensor (MP23ABS1)
  - Humidity sensor (HTS221)
- Ultra-low-power ARM Cortex-M4 microcontroller with DSP and FPU (STM32L4R9)
- Bluetooth application processor v5.2 (BlueNRG-M2) which replaces the SPBTLE-1S Bluetooth Smart connectivity v4.2 module of the board previous batches



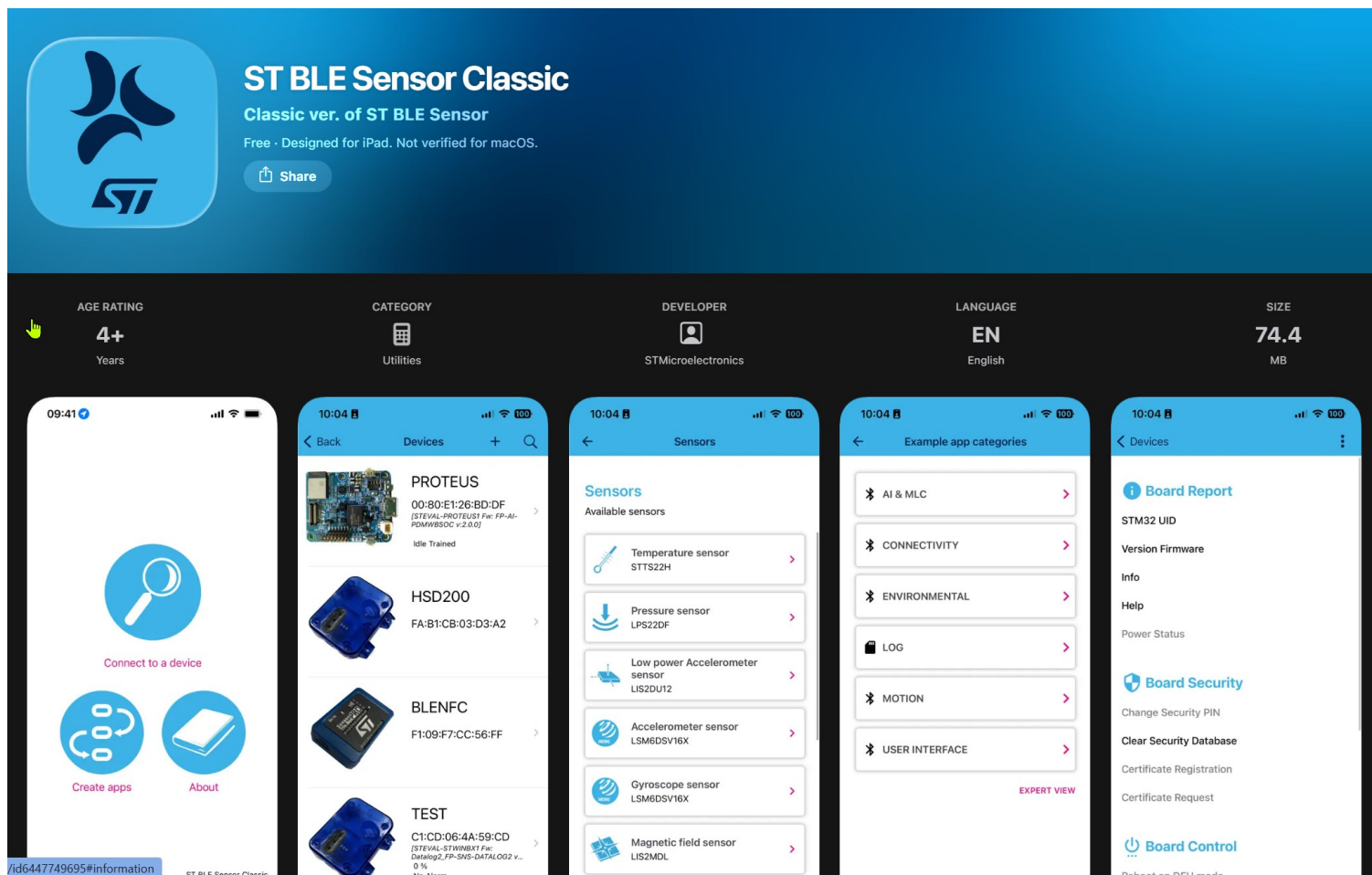
<https://www.st.com/en/evaluation-tools/steval-mksbox1v1.html>

# STEVAL-MKSBOX1V1 SensorTile.box razvojni sistem



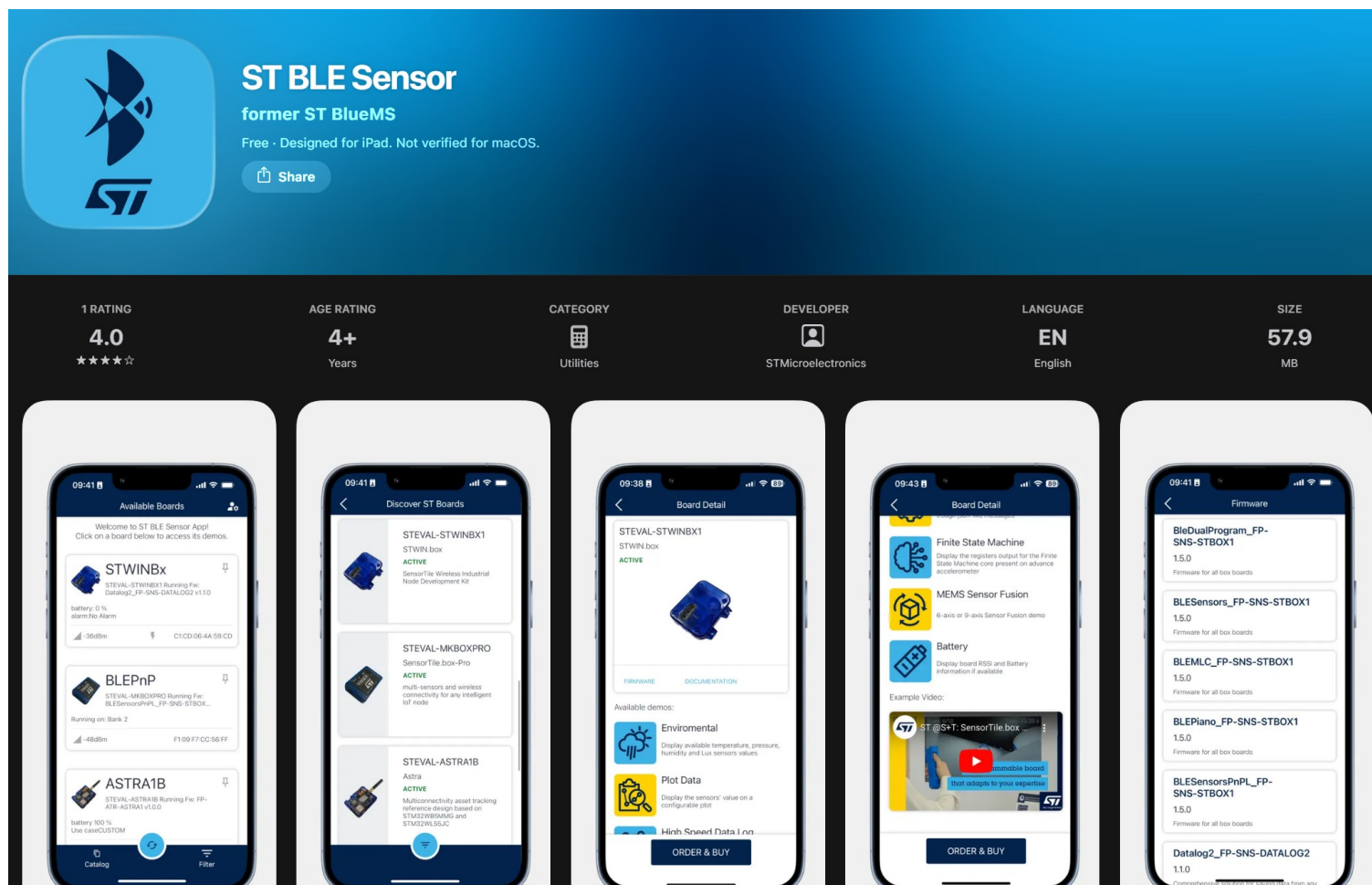
<https://www.st.com/en/evaluation-tools/steval-mksbox1v1.html>

# ST EVAL-MKSBOX1V1 SensorTile.box razvojni sistem



<https://www.st.com/en/evaluation-tools/steval-mksbox1v1.html>

# STEVAL-MKSBOX1V1 SensorTile.box razvojni sistem



<https://www.st.com/en/evaluation-tools/steval-mksbox1v1.html>

# STEVAL-MKSBOX1V1 SensorTile.box razvojni sistem

SensorTile.box wireless multi sensor development kit with user friendly app for IoT and wearable sensor applications

Z naslova <<https://www.st.com/en/evaluation-tools/steval-mksbox1v1.html>>

[https://www.st.com/resource/en/data\\_brief/steval-mksbox1v1.pdf](https://www.st.com/resource/en/data_brief/steval-mksbox1v1.pdf)

How to use the wireless multi-sensor development kit with customizable app for IoT and wearable sensor applications

[https://www.st.com/resource/en/user\\_manual/um2580-how-to-use-the-wireless-multi-sensor-development-kit-with-customizable-app-for-iot-and-wearable-sensor-applications-stmicroelectronics.pdf](https://www.st.com/resource/en/user_manual/um2580-how-to-use-the-wireless-multi-sensor-development-kit-with-customizable-app-for-iot-and-wearable-sensor-applications-stmicroelectronics.pdf)

## **Getting started with the SensorTile.Box (STEVAL-MKSBOX1V1)**

Z naslova <[https://www.youtube.com/watch?v=jJZNMsnRG1U&ab\\_channel=STMicroelectronics](https://www.youtube.com/watch?v=jJZNMsnRG1U&ab_channel=STMicroelectronics)>

## **SensorTile.Box : Basic Mode**

Z naslova <[https://www.youtube.com/watch?v=svbT6eOT5\\_A&ab\\_channel=STMicroelectronics](https://www.youtube.com/watch?v=svbT6eOT5_A&ab_channel=STMicroelectronics)>

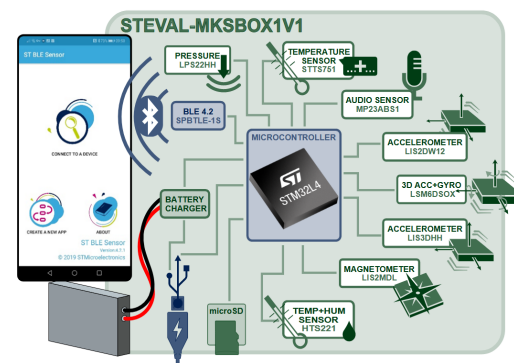
## **SensorTile.Box : Pro mode**

Z naslova <[https://www.youtube.com/watch?v=SHY-izcRNY&ab\\_channel=STMicroelectronics](https://www.youtube.com/watch?v=SHY-izcRNY&ab_channel=STMicroelectronics)>

## **SensorTile.box : Expert Mode**

Z naslova <[https://www.youtube.com/watch?v=A3lj1VXh9SM&ab\\_channel=STMicroelectronics](https://www.youtube.com/watch?v=A3lj1VXh9SM&ab_channel=STMicroelectronics)>

<https://www.st.com/en/evaluation-tools/steval-mksbox1v1.html>



# Edge AI projekt 1 – MNIST CNN na STM32H750B

## STM32H750B-DK

- LCD Touch Screen (480×272 px)
- Cortex-M7 @ 480 MHz + FPU
- 1 MB RAM, 2 MB interni Flash
- 128 MB NOR Flash (MT25TL01G) @ 0x90000000
- → uteži nevronske mreže v zunanjem Flash-u

## CNN arhitektura in potek

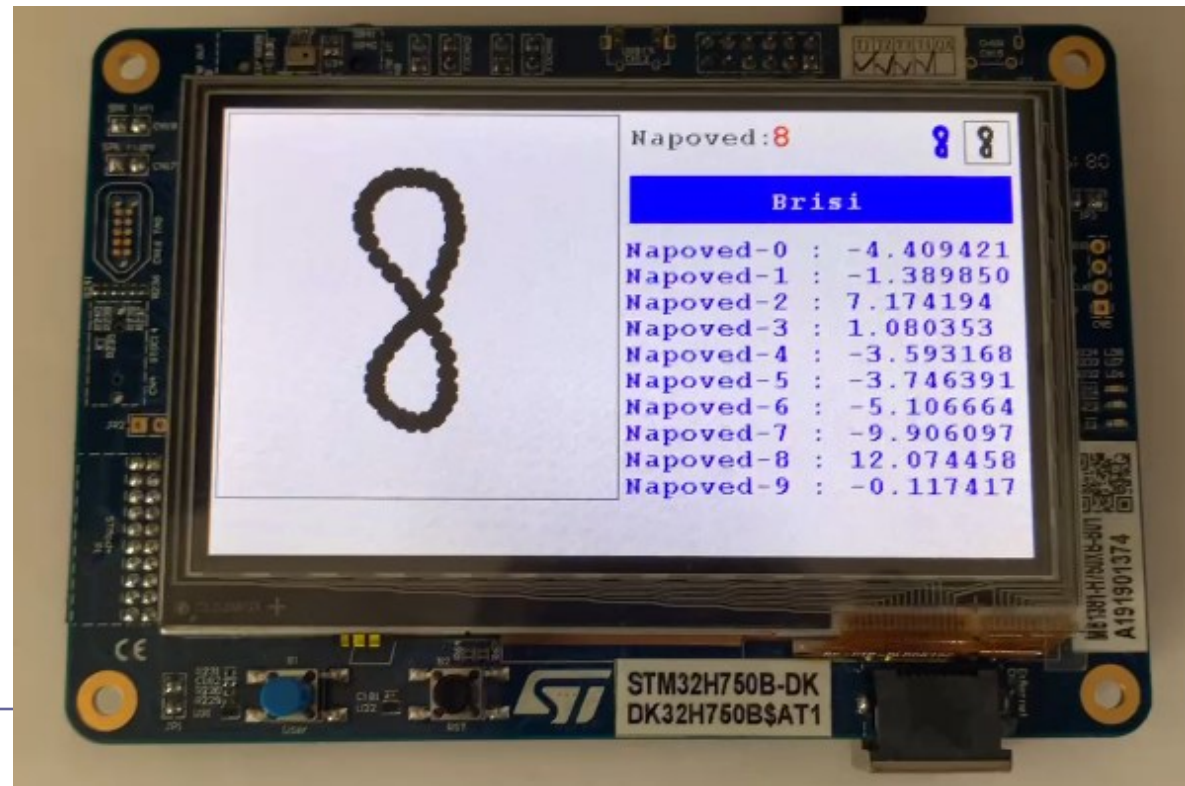
- MNIST: 60K učnih + 10K testnih slik (28×28 px)
- CNN: Conv2D(32) → Pool → Conv2D(64) → Dense(64) → Softmax(10)
- Točnost: ~95–98% na testni množici
- Kvantizacija float32 → int8: 4× manjše uteži
- STM32Cube.AI → optimizirana C koda

**Zakaj NOR Flash za uteži? Interni Flash (2 MB) ne zadostuje za celoten model.**

*GitHub: [github.com/bernardkuchler/STM32H750B-DK\\_with\\_MNIST\\_handwriting\\_CNN](https://github.com/bernardkuchler/STM32H750B-DK_with_MNIST_handwriting_CNN)*

# Edge AI projekt 1 – MNIST CNN na STM32H750B

- Flash: 128 KB + 2×512 MB zunanji NOR flash (Quad SPI)
- LCD zaslon na dotik
- STM32H750XBH6 (480 MHz CPE)
- Pytorch in X-CUBE-AI (ONNX)
- 200 KB nevronska mreža



## Edge AI projekt 2 –

# Diploma: Uporaba modelov strojnega učenja v vgrajenih sistemih



## Uporaba modelov strojnega učenja v vgrajenih sistemih

[Kuchler, Bernard](#)

[Rozman, Robert](#)

[Več o mentorju...](#)

### Izvleček

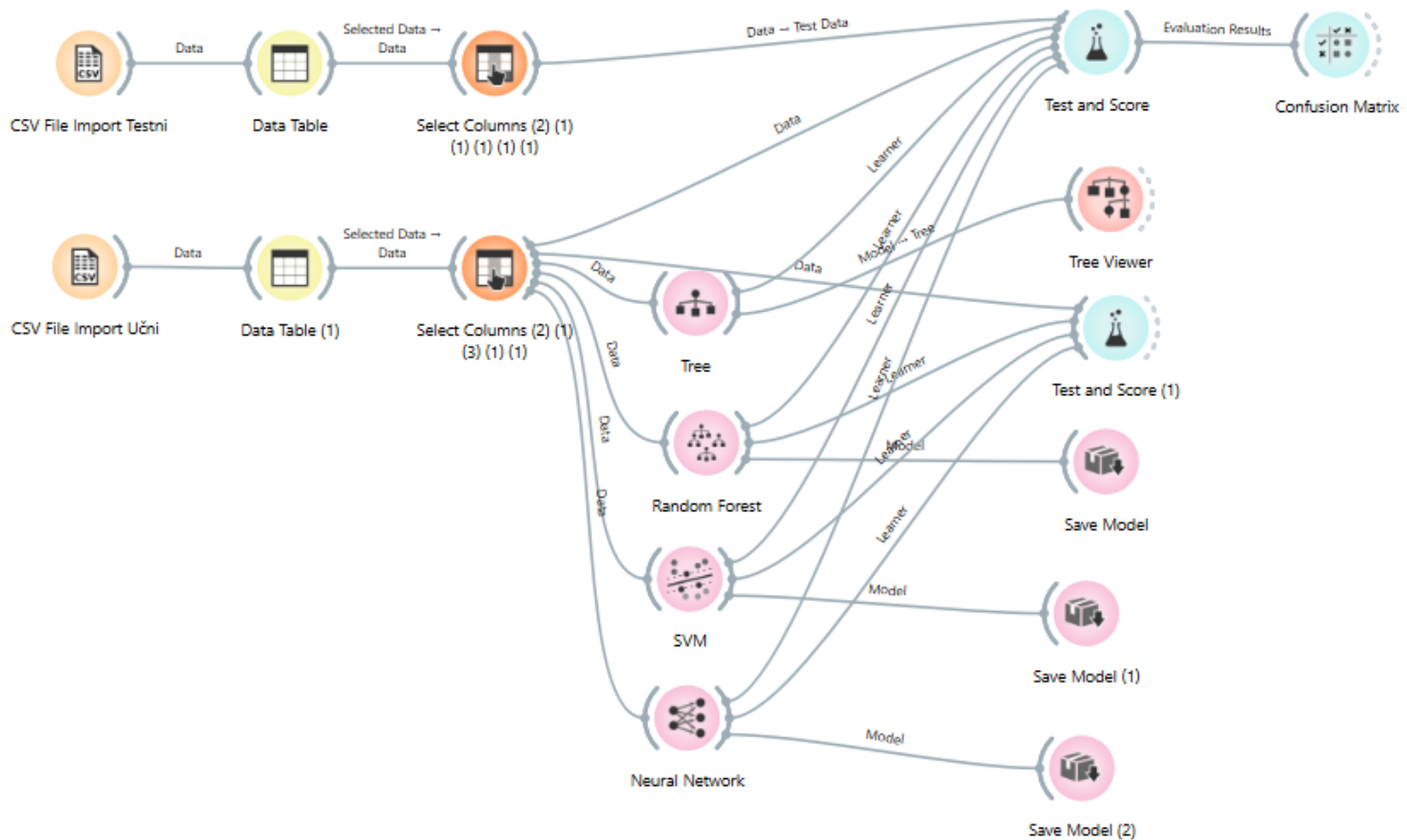
Cilj diplomske naloge je izkoristiti prednosti splošnih okolij za učinkovito tvorbo modelov strojnega učenja (Orange) in te modele ustrezno prilagoditi za izvedbo v vgrajenih sistemih. Slednji namreč imajo omejene vire in prilagoditev modelov pogosto ni enostavno opravilo. Splošna orodja te prilagoditve modelov običajno ne podpirajo, obstajajo pa namenska orodja proizvajalcev vgrajenih sistemov za tvorbo prilagojenih modelov, ki pa so precej bolj omejena glede funkcionalnosti in izbire modelov. V tej nalogi smo zato poskušali izkoristiti prednosti obeh vrst razvojnih okolij. Modele smo tvorili v splošnem orodju Orange in jih nato s pomočjo različnih pristopov in namenskih orodij prilagajali za učinkovito uporabo v vgrajenih sistemih. Pri tem smo napisali več različnih dodatnih programov v programskih jezikih Python in C. Prispevek našega dela so poleg programov še splošna priporočila za uporabo modelov v vgrajenih sistemih in podrobno opisani postopki za enostavno izdelavo modelov strojnega učenja v okolju Orange in njihovo učinkovito prilagoditev za uporabo v vgrajenih sistemih. Na tej osnovi lahko odločitve in postopke izvedejo tudi uporabniki z manj izkušnjami na področju strojnega učenja. Omenjene postopke smo preizkusili na dveh praktičnih primerih klasifikacije in razpoznavne ter analizirali učinkovitost in uspešnost modelov v vseh korakih od splošnega okolja do uporabe na vgrajenih sistemih. Ugotovili smo, da so modeli primerljivo uspešni tudi pri uporabi na bolj omejenih vgrajenih sistemih. Vse izdelano v okviru diplomske naloge je javno dostopno v repozitoriju GitHub [11] in na voljo za nadaljnje izboljšave.

Z naslova <<https://repozitorij.uni-lj.si/lzpisGradiva.php?id=150167>>

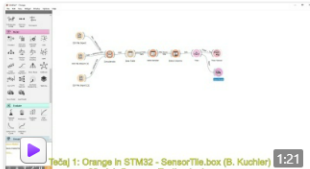
GitHub: [github.com/bernardkuchler/Orange-on-SensorTile.box](https://github.com/bernardkuchler/Orange-on-SensorTile.box)

# Edge AI projekt 2 –

## Diploma: Uporaba modelov strojnega učenja v vgrajenih sistemih



## UI: Orange in STM32 platforme (B. Kuchler)

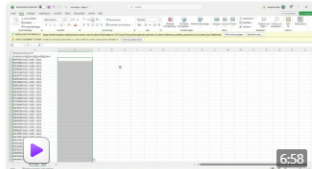


1:21

LAPSy Embedded Academy

VIN TUT 01.01 Orange in STM32 - SensorTile.box (B. Kuchler)\_Krajši...

Rozman, Robert  
Edited April 14, 2024

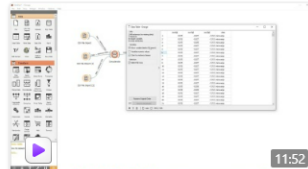


6:58

LAPSy Embedded Academy

VIN TUT 01.01 Orange in STM32 - SensorTile.box (B. Kuchler)\_Orange -...

Rozman, Robert  
Edited April 14, 2024




11:52

LAPSy Embedded Academy

VIN TUT 01.02 Orange in STM32 - SensorTile.box (B. Kuchler)\_Orange -...

Rozman, Robert  
Edited April 14, 2024

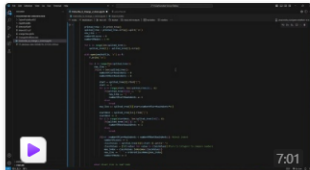


5:50

LAPSy Embedded Academy

VIN TUT 01.03 Orange in STM32 - SensorTile.box (B. Kuchler)\_Orange -...

Rozman, Robert  
Edited April 14, 2024

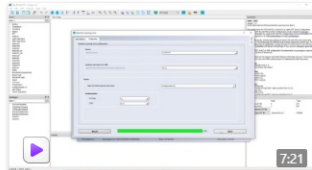


7:01

LAPSy Embedded Academy

VIN TUT 01.04 Orange in STM32 - SensorTile.box (B. Kuchler)\_Orange -...

Rozman, Robert  
Edited April 14, 2024

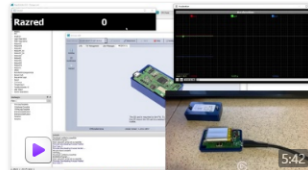


7:21

LAPSy Embedded Academy

VIN TUT 01.05 Orange in STM32 - SensorTile.box (B. Kuchler)\_Orange -...

Rozman, Robert  
Edited April 14, 2024

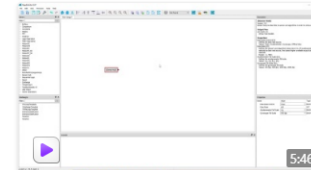


5:42

LAPSy Embedded Academy

VIN TUT 01.06 Orange in STM32 - SensorTile.box (B. Kuchler)\_Orange -...

Rozman, Robert  
Edited April 14, 2024




5:46

LAPSy Embedded Academy

VIN TUT 01.07 Orange in STM32 - SensorTile.box (B. Kuchler)\_STM32 -...

Rozman, Robert  
Edited April 14, 2024

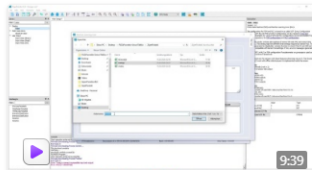


6:30

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VIN TUT 01.08 Orange in STM32 - SensorTile.box (B. Kuchler)\_STM32 -...

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9:39

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VIN TUT 01.09 Orange in STM32 - SensorTile.box (B. Kuchler)\_STM32 -...

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4:30

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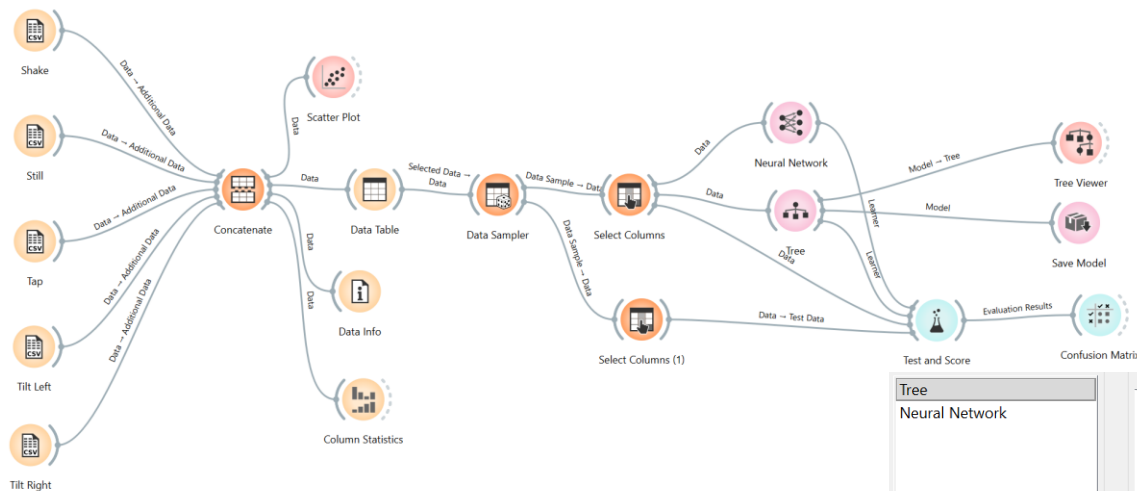
VIN TUT 01.10 Orange in STM32 - SensorTile.box (B. Kuchler)\_STM32 -...

Rozman, Robert  
Edited April 14, 2024

[Tečaji, tutoriali, predavanja...](https://unilj.sharepoint.com/sites/LAPSYEmbeddedAcademy/SitePages/Te%C4%8Daji.aspx)

<https://unilj.sharepoint.com/sites/LAPSYEmbeddedAcademy/SitePages/Te%C4%8Daji.aspx>

# Edge AI projekt 3 – SensorTile.box: zajem, učenje in klasifikacija gibov v 5 razredov

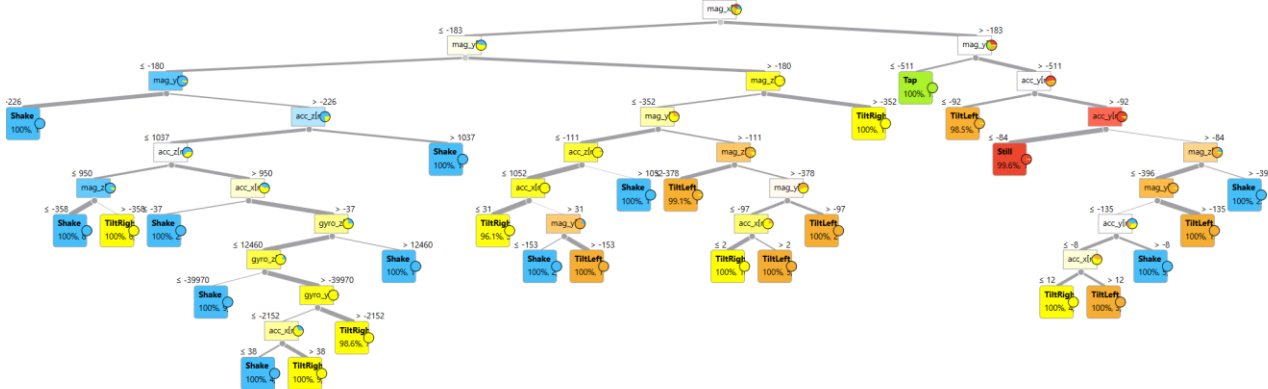


Model	AUC	CA	F1	Prec	Recall	MCC
Tree	0.997	0.989	0.989	0.989	0.989	0.986
Neural Network	1.000	0.996	0.996	0.996	0.996	0.995

Tree  
Neural Network

Output  
 Predictions

		Predicted					
		Shake	Still	Tap	TiltLeft	TiltRight	Σ
Actual	Shake	1474	0	0	19	16	1509
	Still	0	1485	0	0	0	1485
	Tap	0	0	1515	0	0	1515
	TiltLeft	6	6	0	1498	10	1520
	TiltRight	20	0	0	9	1805	1834
Σ		1500	1491	1515	1526	1831	7863



# 12.b VIN projekt in SensorTile.box

## ■ Praktična naloga - VIN Projekt

- Razvojne plošče
- Viri (gradiva, posnetki, primeri, ...)
- Osnovna projekta v CubeIDE:
  - CubeMX (HAL knjižnica, BSP) – STM32H7, STM32F4
    - CubeMX – osnovni projekt (GPIO – tipka, LED diode, USART)
    - BSP – osnovni projekt (Touch, LCD)

## ■ Edge Computing

## ■ SensorTile.box (kompaktna Edge AI razvojna platforma)

## ■ STM AI ekosistem in Orange Data Mining

# STM AI Ekosistem

## Razvojna orodja

- STM32CubeIDE
- STM32CubeMX
- AlgoBuilder (grafično)
- VS Code + STM32 ext.

## ML orodja

- STM32Cube.AI
- MEMS Studio
- UniCleoGUI
- X-CUBE-AI paket
- Edge Impulse (oblak)

## Strojna oprema

- STM32H7 serija
- SensorTile.box
- NUCLEO plošče
- STM32H750B-DK

**NanoEdge AI Studio: AutoML pristop – brez ročnega programiranja modela · anomaly detection · od 1 kB RAM**

- STM32Cube.AI – konverzija Keras/TFLite → optimizirana C koda za STM32
- AlgoBuilder – vizualno grafično orodje (podobno Simulinku), izvoz podatkov prek USB CDC / BLE
- Edge Impulse – oblačna platforma: spektralna analiza, MFCC, deploy na STM32 / Arduino

# Orange Data Mining – vizualno ML orodje

Odprtokodna platforma FRI (Biolab skupina, Univerza v Ljubljani)  
[orangedatamining.com](http://orangedatamining.com)

## Uvoz & predprocesiranje

- File (CSV/Excel/tab)
- Data Sampler
- Preprocess (normalize, impute)
- Feature Constructor
- Select Columns

## Modeli ML

- kNN · Odločitveno drevo
- Random Forest
- SVM · Naive Bayes
- Neural Network (MLP)
- Logistic Regression

## Vrednotenje

- Test and Score (CV, F1, AUC)
- Confusion Matrix
- ROC Analysis
- t-SNE vizualizacija
- Scatter Plot / Heat Map

### Orange potek za IMU podatke:

*File (CSV) → Preprocess (z-score) → Feature Constructor → Random Forest / kNN / SVM → Test & Score → Confusion Matrix*