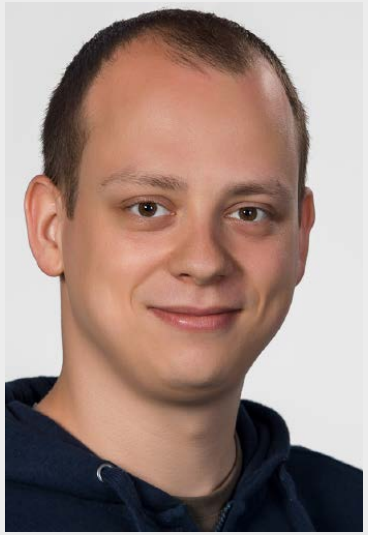
Attila Géczy



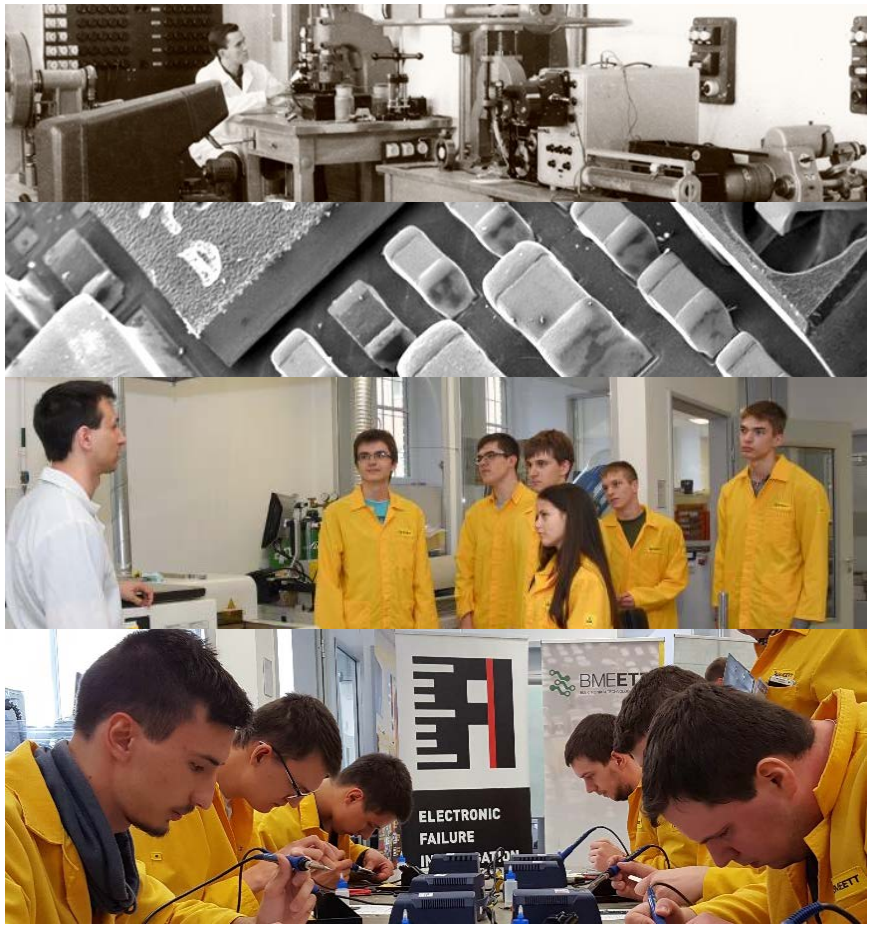
Application of Grid-Eye IR sensor for enhanced HMI and OSH purposes in Industry 4.0 reflow soldering environment

Attila Géczy, Tálas D. Mátyás, Judit Kámán, Gábor Harsányi

Attila Géczy is an associate professor at Budapest University of Technology, Dept. of Electronics Technology. His main fields include packaging technologies, reflow, heat transport, modelling, green electronics, applied sensors and e-education. As a commissioner for the Dean, he works on PR-related activities of the faculty. As the president of the IMAPS Hungary Chapter (subsidiary of MELT), he works on the reactivation of the chapter activities.

THE DEPARTMENT:

- Department of Electronics Technology - since 1964



- ***electronic components, circuits and systems***
- ***interconnection and packaging technology of microelectronics circuit modules***

OUR COMPETENCE FIELDS:

- ***PCB and circuit design & manufacturing;***
- ***CAD, modelling, simulations;***
- ***Assembly technologies: SMT, THT;***
- ***Failure investigation;***
- ***Biosensors and nanometrology;***
- ***Lasers; Thick & Thin Films;***
- ***Applied sensors;***

WE CONNECT CHIPS AND SYSTEMS

INTRODUCTION:

Sensor research at our department since the 80's.

- at ***Budapest University of Technology and Economics (BME)***, Hungary

THE TEAM

BIOSENSORS

Prof. Gábor Harsányi

Attila Bonyár

Hunor Sántha

Judit Kámán

APPLIED SENSORS

Attila Géczy

Amine Mohamed Alaya

Dániel Straubinger

SENSOR RELATED PROJECTS:

- *Biosensors*
- *Sensor characterization*
- *Microfluidics*

- *Applied sensors in I4.0 manufacturing*
- *Applied sensors in automotive*
- *Wearables based on applied sensors and IoT devices*

The applied sensor research is supported by the National Research, Development and Innovation Fund (TUDFO/51757/2019-ITM) Thematic Excellence Program.

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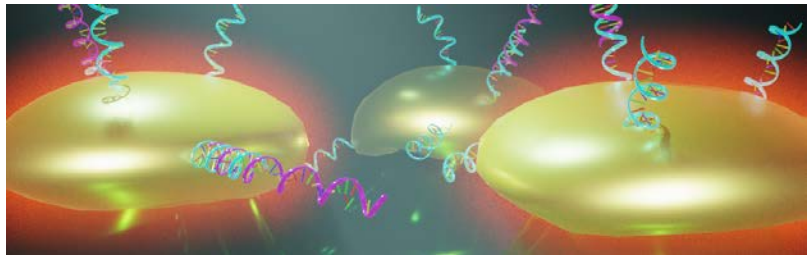
Numerous BSc and MSc students were working on the topic throughout the years.

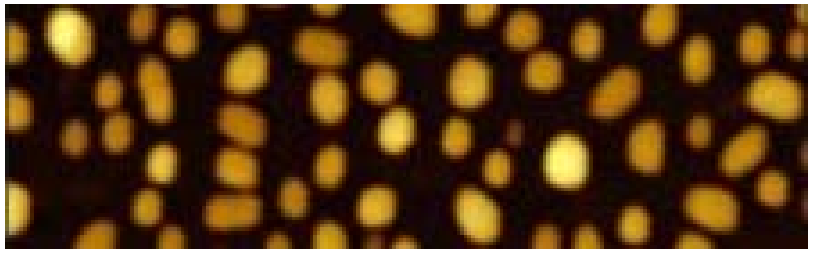
DIFFERENT SENSOR PROJECTS:

EXAMPLES FROM OUR DEPT:

ELECTROCHEMICAL AND OPTICAL BIOSENSORS

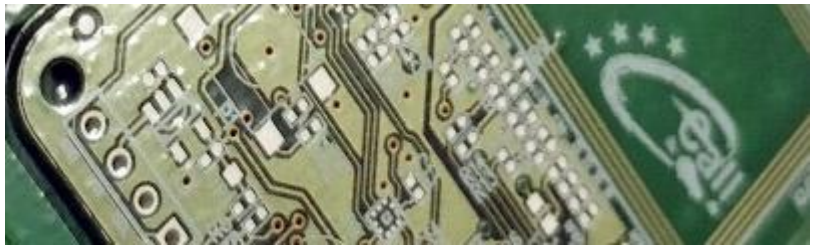


Optical nucleotide nanobiosensor

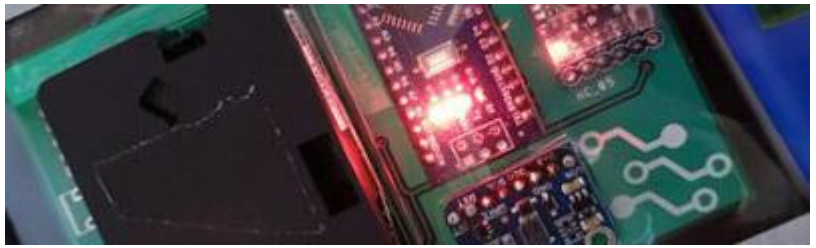


Nanofabrication, nanosensors;
Microfluidics

APPLIED SENSORS, PLATFORMS



Automotive HMI device for eCall purposes
(pressure sensor – airbag detection)



Wearable cluster for air quality
monitoring in smart labs and cities

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MOTIVATION:

- Applied sensors point to smart manufacturing in Industry4.0.
- New applications may lead to better control and improved manufacturing quality.
- Cheap sensors, easy to develop card computer platforms with IoT compatiblity.
- Path for new ideas!

- New Industry 4.0 lab environment for demonstrational purposes at the Faculty.
- Demonstration platform with ETT-compentency.
- New ideas to enhance reflow soldering.

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THE IDEA:

- Enhancement of a reflow oven
- Thermal management?
- Enhanced Human-Machine Interface?
- Improved Occupational Safety and Health (OSH) aspects?
- Possibility for retrofitting?

- Better user experience and online availibility;
- Control and validation;
- Additional signals for operators.
- Hot surfaces, hot surroundings of ovens. Danger!
- To apply on bench-top or in-line ovens.

Selected examples of applied sensors in the latest literature:

Andrea Benešová, Martin Hirman, Karel Šíma, František Steiner, Aleš Hamáček, Jiří Tupa, IoT unit for reliability improvement during of the product life cycle, IMAPS Poland 2018 Conference, 23 - 26 September, Gliwice, Poland

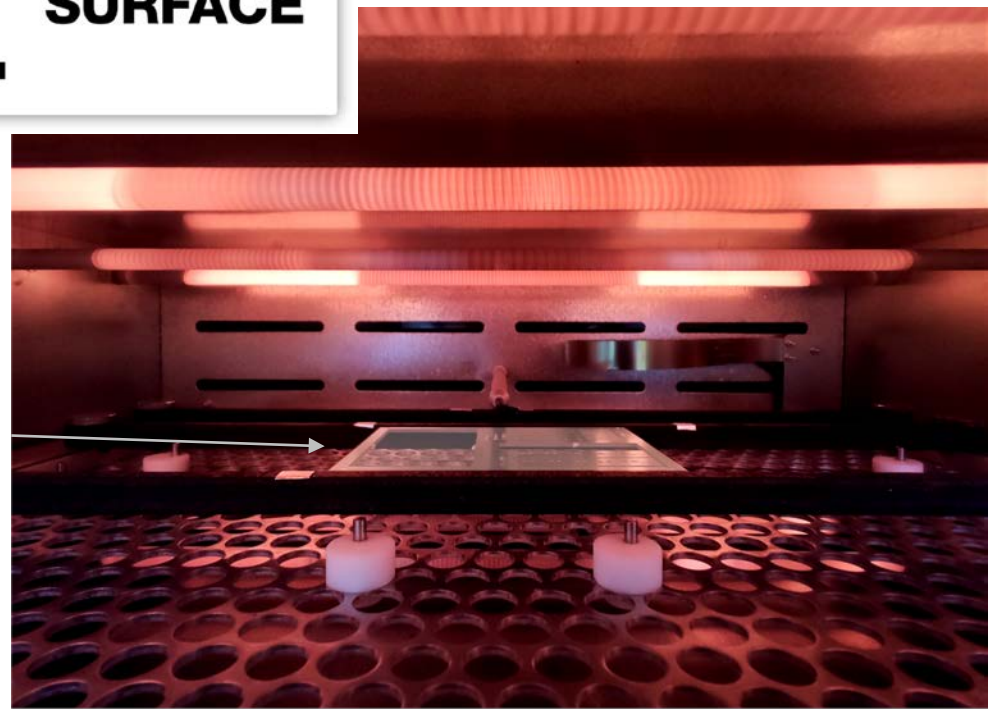
Paul Wild, Hans Bell, Lukas Ziegler, Convection Soldering Systems in the Age of Industry 4.0 Smart Reflow Permits Predictive Maintenance - Case Study, *Rehm Thermal Systems GmbH*, February 2017

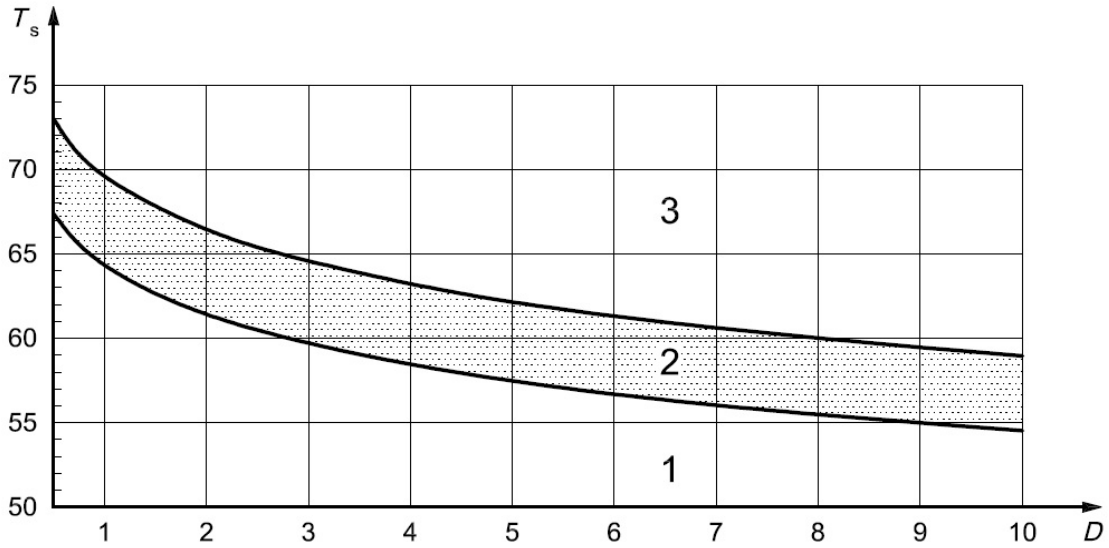
Karanjkar, N., Joglekar, A., Mohanty, S., Prabhu, V., Raghunath, D., & Sundaresan, R. Digital Twin for Energy Optimization in an SMT-PCB Assembly Line. 2018 IEEE International Conference on Internet of Things and Intelligence System (IOTAIS), 2018. doi:10.1109/iotais.2018.8600830

ERGONOMICS:

ISO 13732-1:2006; Ergonomics of the thermal environment - Methods for the assessment of human responses to contact with surfaces - Part 1: Hot surfaces.

Hot workzone of an IR oven.





Burn threshold of a metal touched by the skin of an operator;
1 – no-burn zone; 2 – uncertain zone; 3 – burn zone;
(Ts, material surface temperature [°C];
D, contact period of skin and surface [s])

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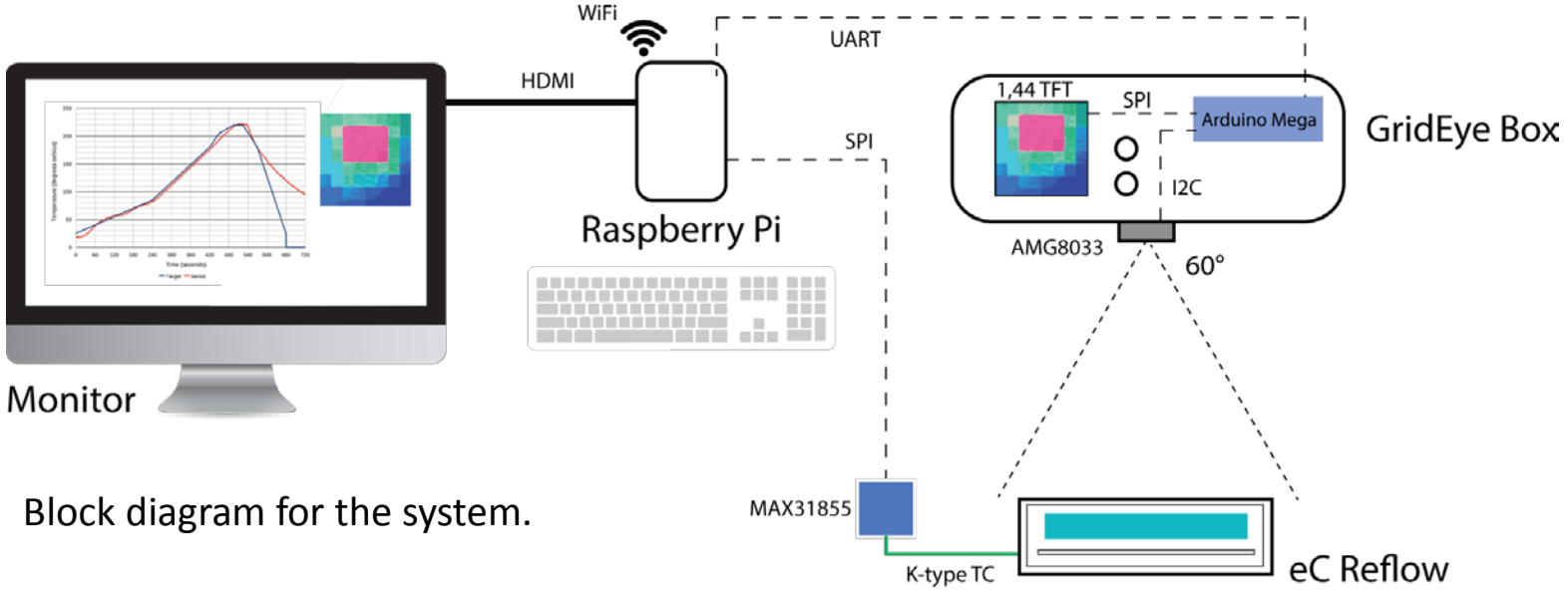
SUGGESTED SETUP:

GRID-EYE SENSOR

EC IR REFLOW MATE

ARDUINO MEGA & RASPBERRY PI CARD COMPUTERS



Block diagram for the system.

- Industrial, but small form-factor reflow oven
- Card computers with I4.0 focus and IoT compatiblity: easy development and system integration
- Easy to setup demonstration for the capability of the sensor in HMI and OSH upgrades.

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HW SPECIFICATION:

EXACT HW COMPONENTS:

- **Eurocircuits eC Reflow Mate** oven. Bench-top form factor, infra-based heating with PC or standalone control;
- Adafruit **MAX31855** + **K type** thermocouple;
- Adafruit **AMG8833**: Grid-Eye sensor breakout board;
- **Arduino MEGA**: handling AMG8833 standalone or connected mode;
- **Raspberry Pi 3.0** – Master device, with internet connectivity and web server functionality.
- Adafruit **1.44” TFT LCD** – display for standalone working of the Grid-Eye unit.

COMMUNICATION:

- Raspberry Pi - Adafruit MAX31855: SPI
- Arduino Mega – Adafruit AMG8833: I2C
- Arduino Mega – TFT: SPI
- Raspberry Pi – Arduino Mega: UART
- Raspberry Pi – WiFi connection to dept. Network.
- (LoRa for campus!)

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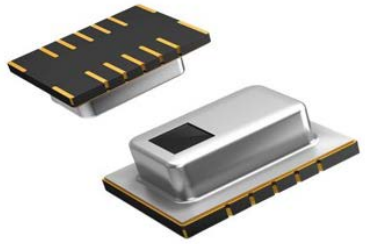
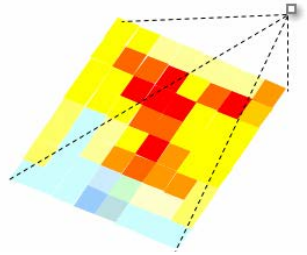
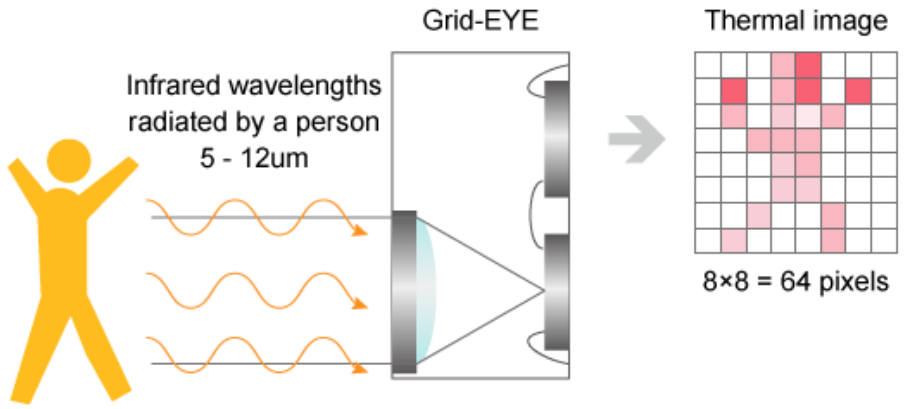
THE SENSOR



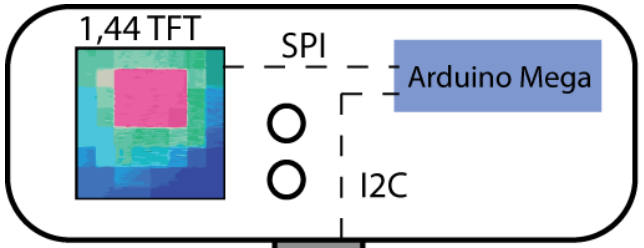


GRID-EYE SENSOR concepts

Human detection



Based on IR radiation



GridEye Box

eC Reflow

Investigated HMI and OSH submodule

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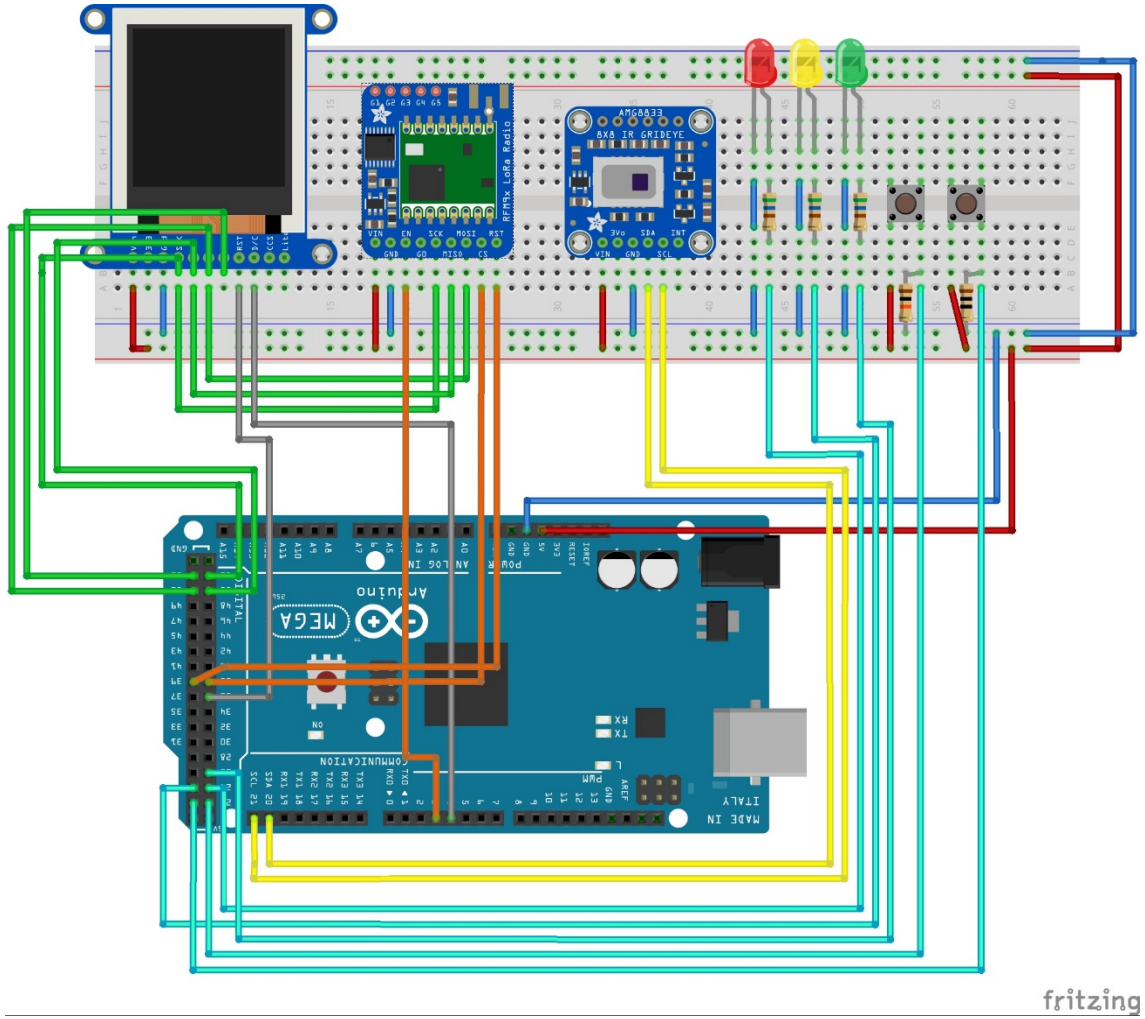
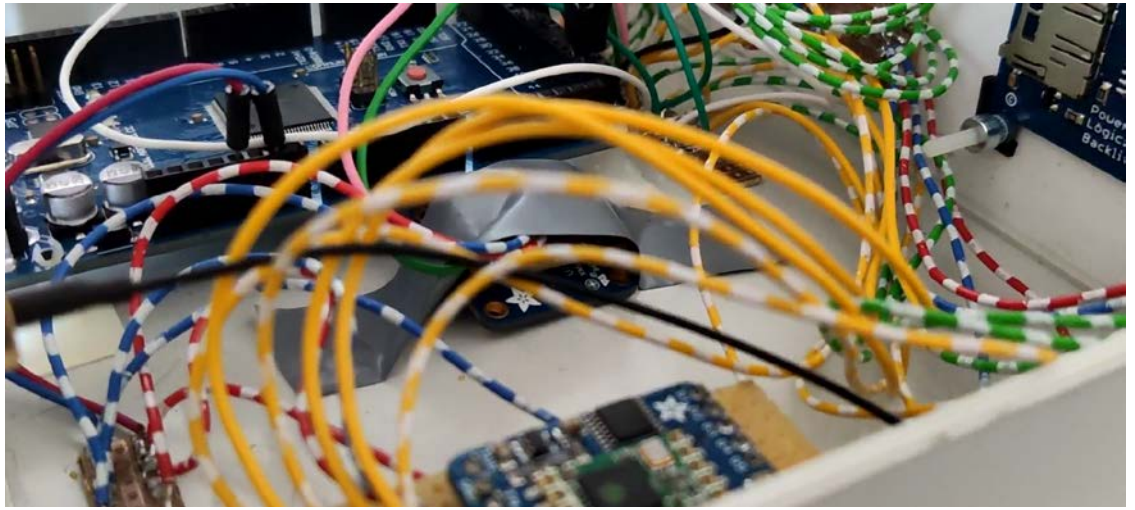
WIRING DIAGRAM OF SUBMODULE



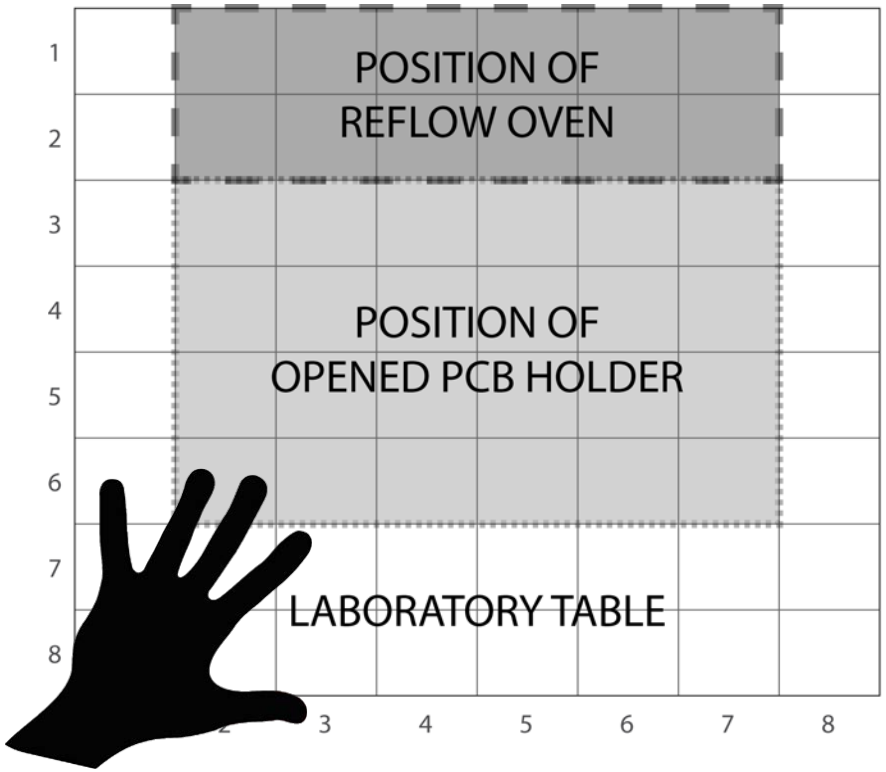
- Board prototype to boxed prototype.
- Assembled in Fritzing;
- The circuit is carried over to a packaged box version;

Arduino MEGA was required for handling standalone mode.

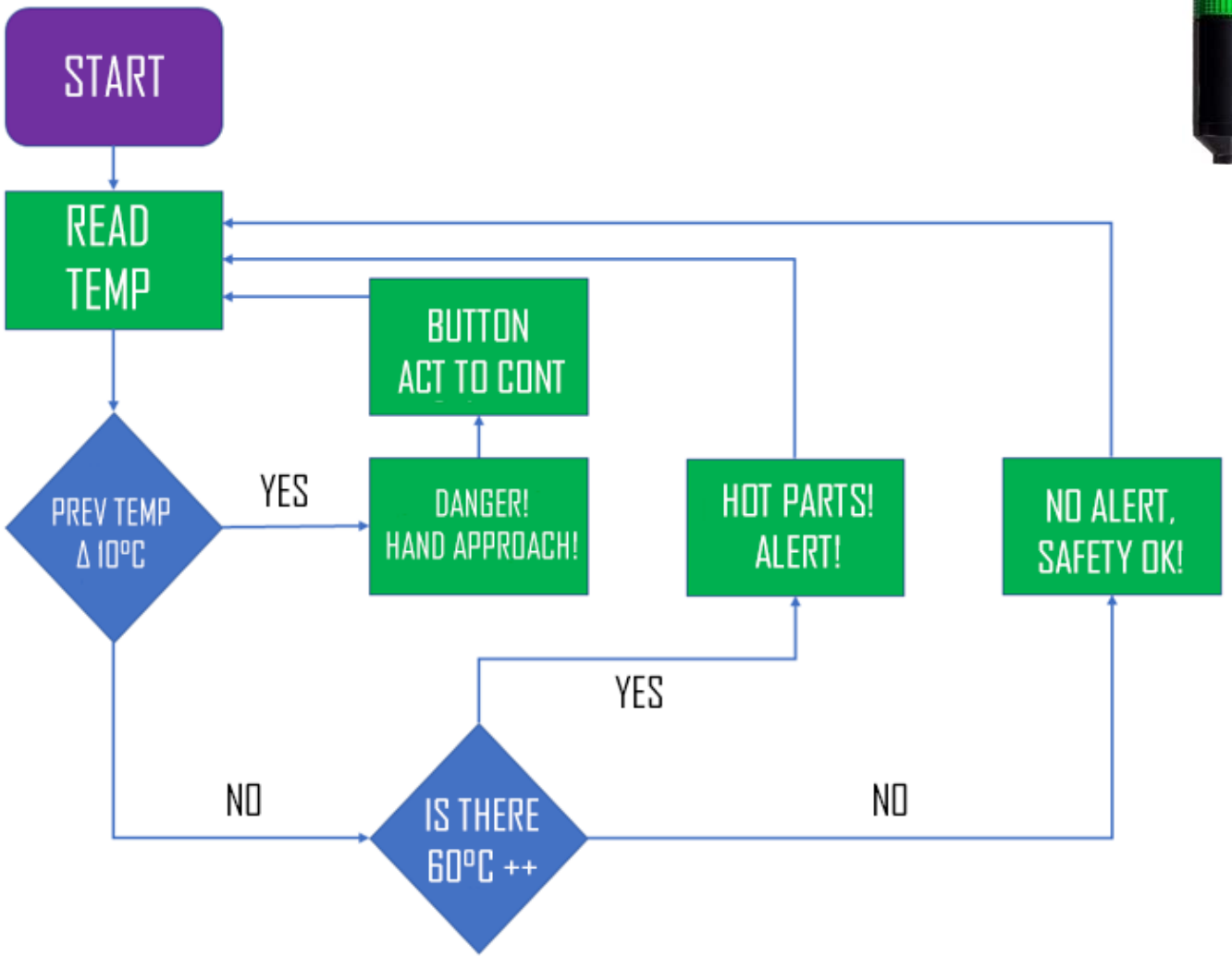


USE CASE OF OPERATION

60x60 cm view



7,5x7,5 cm per pixel



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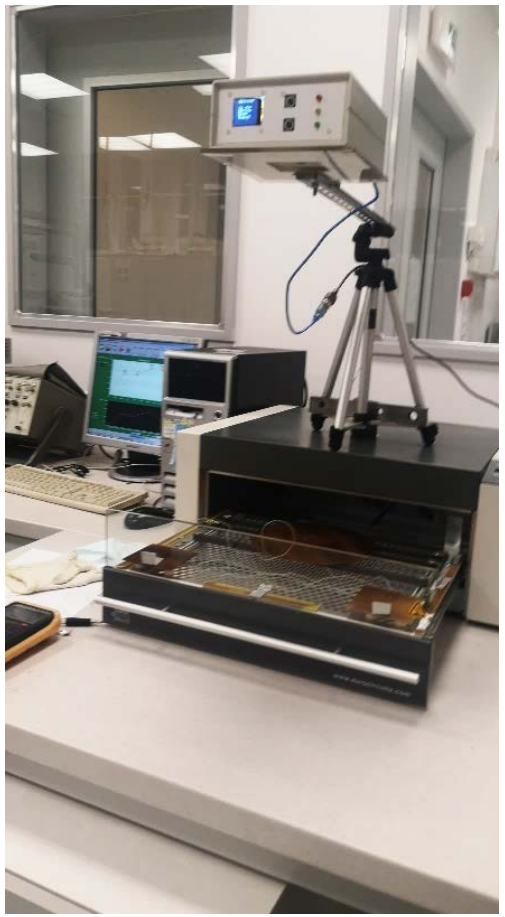
ACTUAL TEST SETUP IN LAB ENVIRONMENT



View on the system from the operators point. Note the green line – increased temperature of oven!

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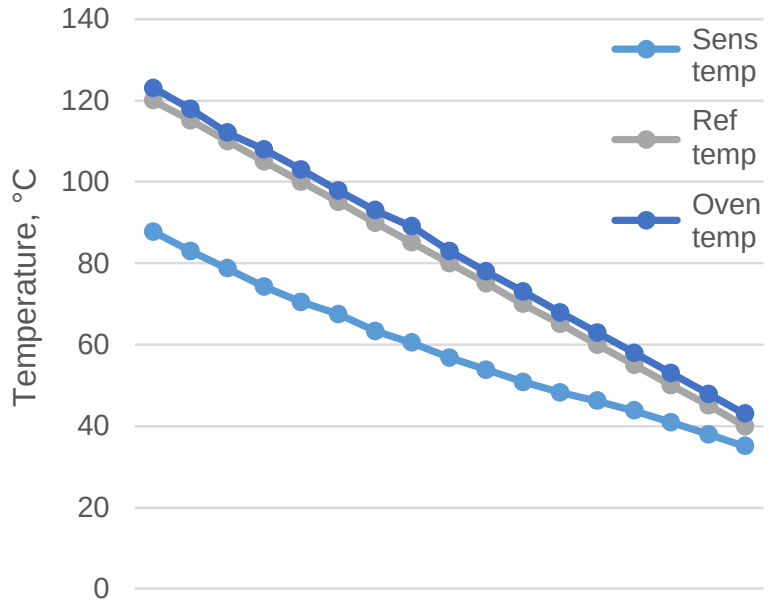
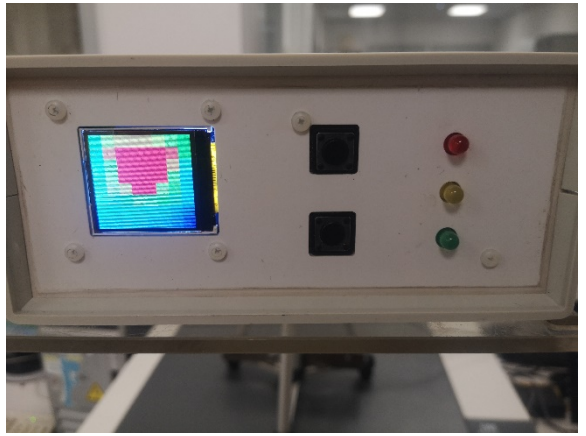
VALIDATION



Validation of temperature values at reference temperatures. (120 -> 40 °C in 5 °C steps) on the surface of a PCB after opening of the oven;

"Sens" – GridEye data, "Ref" – reference K-type thermocouple, "Oven" – data recorded by oven thermocouple



Opened and closed oven doors, highlighted by the hot zones on the display.

Standalone mode options and operational menu.

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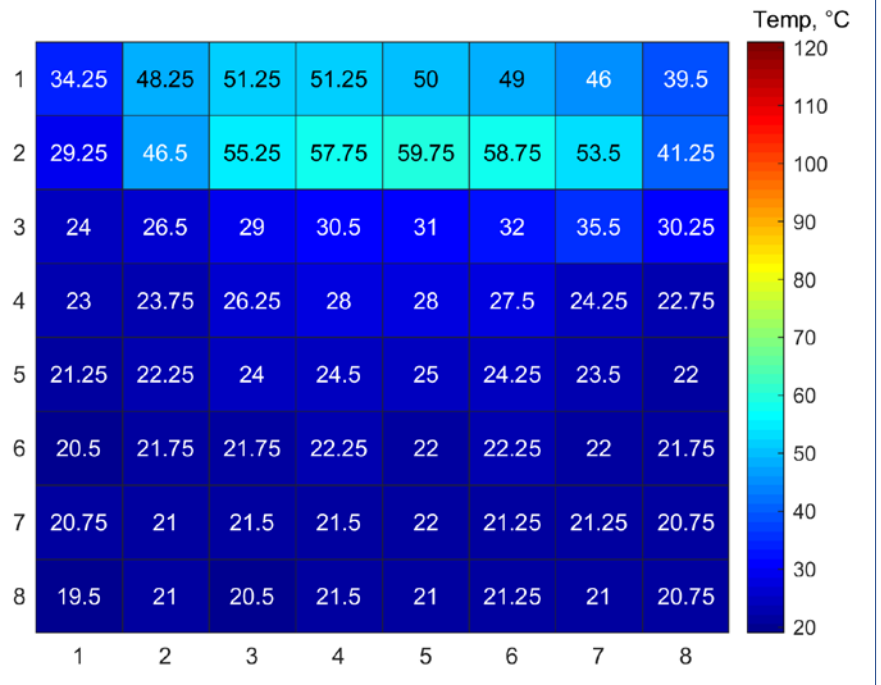
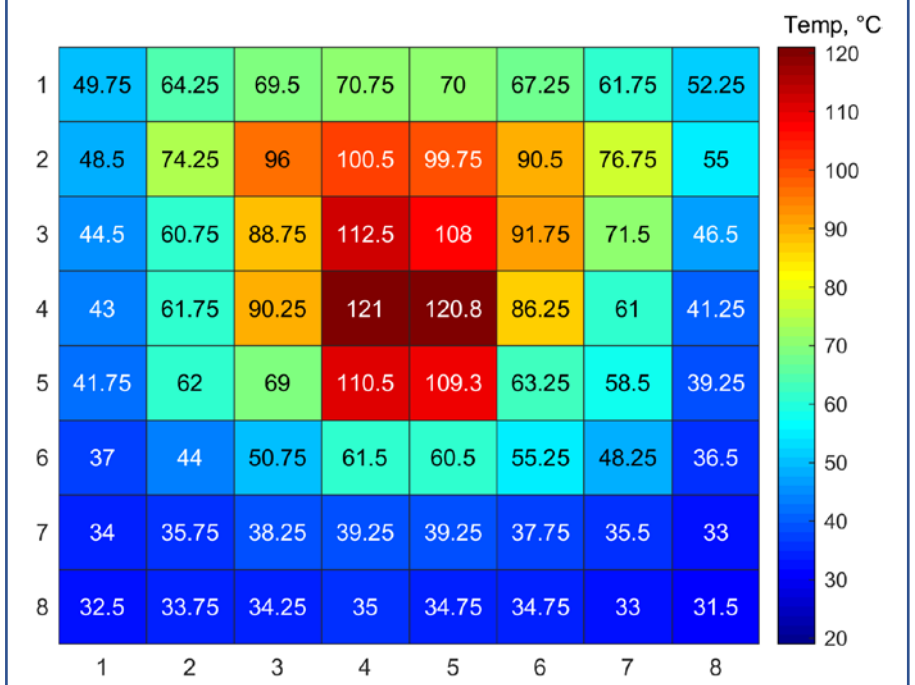
RESULTS:



Left: *Sensor data with closed oven door, during reflow process (XY values: sensor measurement points)*



Right: *Sensor data with opened oven door, after reflow process (XY values: sensor measurement grid points)*

- **Conclusions for application:**
- Successful identification of closed oven separated from laboratory ambience
- Successful identification of opened door and PCB load on the shelf.

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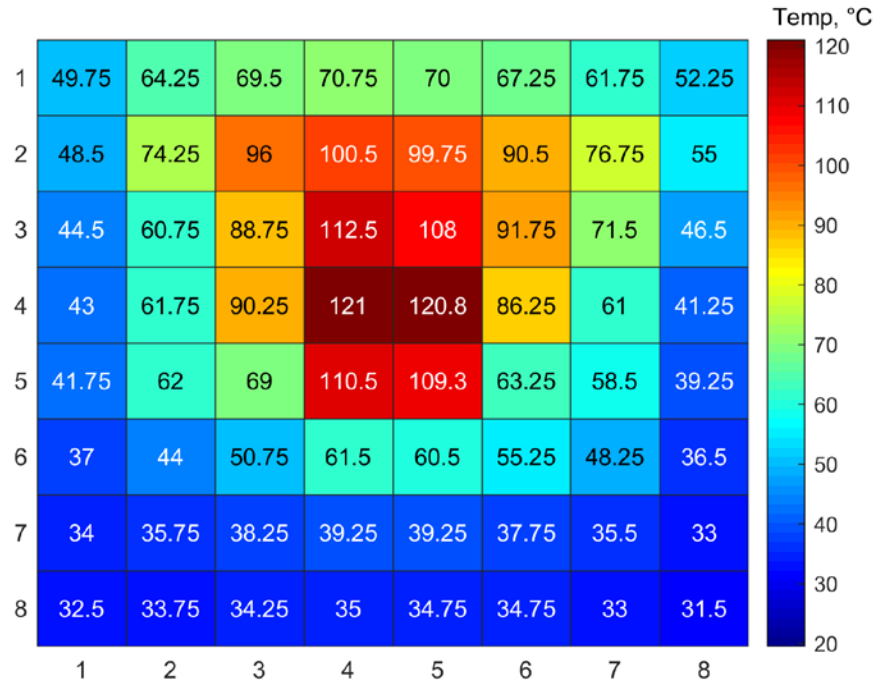
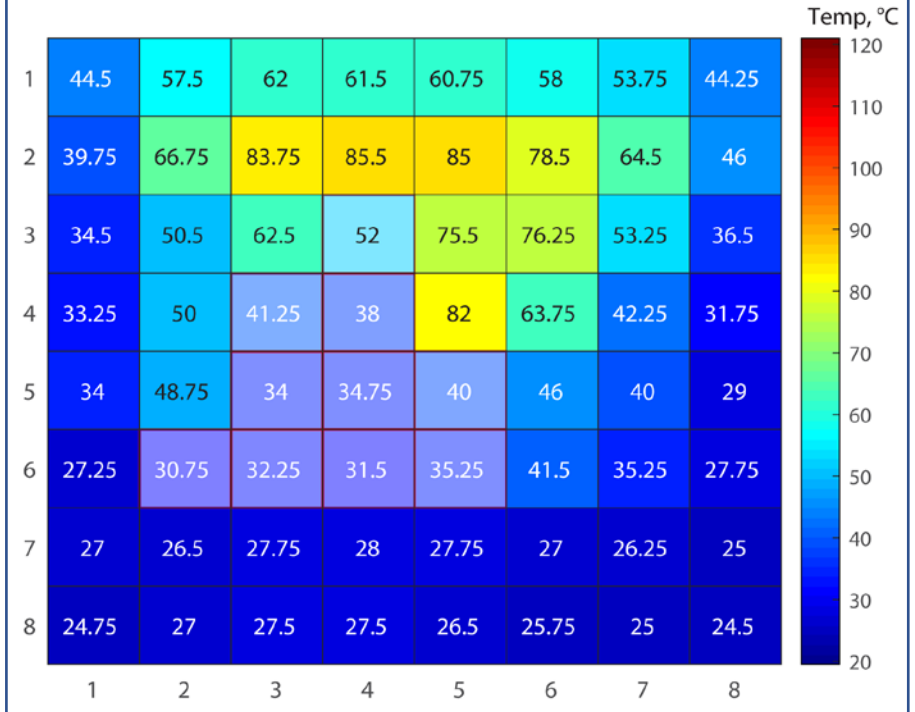
RESULTS:



Left: *Sensor data with opened oven door, after reflow process (XY values: sensor measurement grid points)*



Right: *Sensor data with opened oven door, after reflow process (XY values: sensor measurement grid points)*

- **Conclusions for application:**
- Successful identification of arriving hand.
- Absolute temperature values are not reliable, however overall changes are quantitatively useful.

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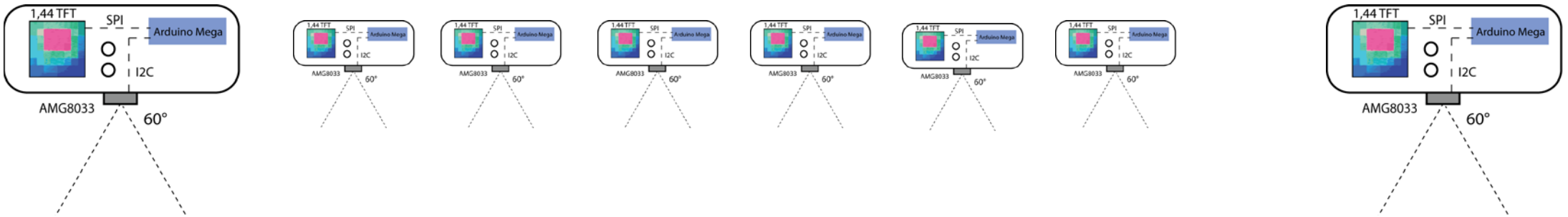
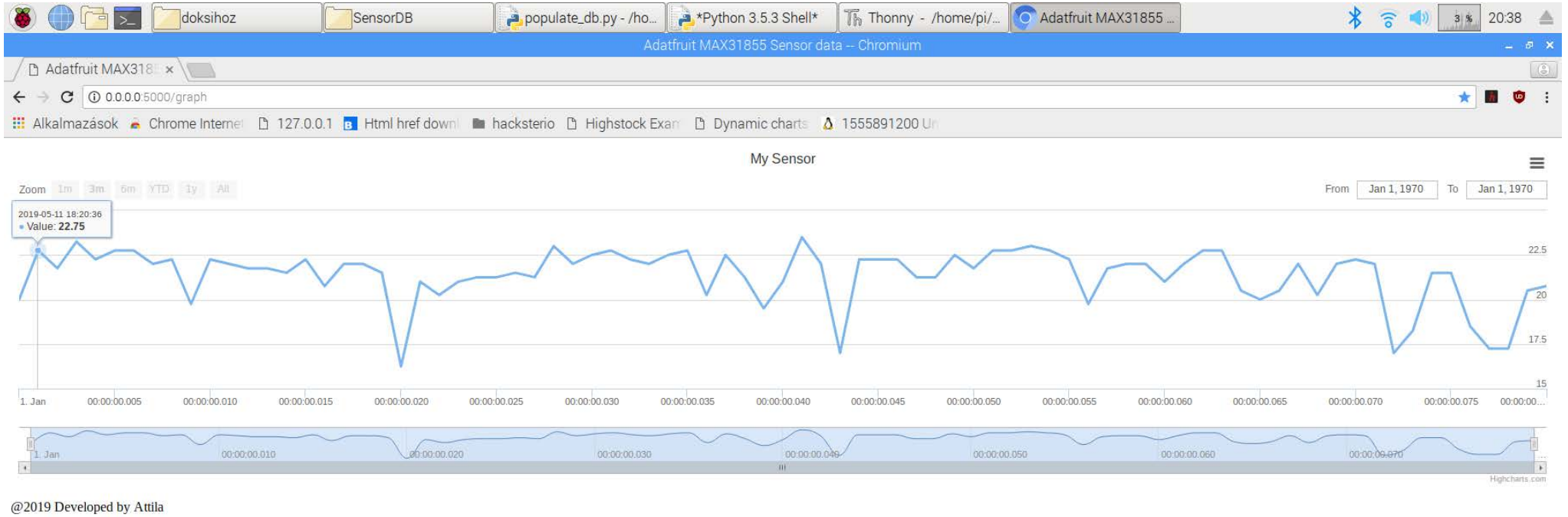
POSSIBLE FUTURE APPLICATIONS?



Picture source: Faroadsmt.com

WEBSERVER ON RPI



- Monitoring real time reflow temperatures
- Monitoring HMI & OSH feedback
- Observable even from a mobile phone.

Attila Hannos: Expanding the sensor system of a reflow oven according to Industry 4.0 directives, MSc Thesis

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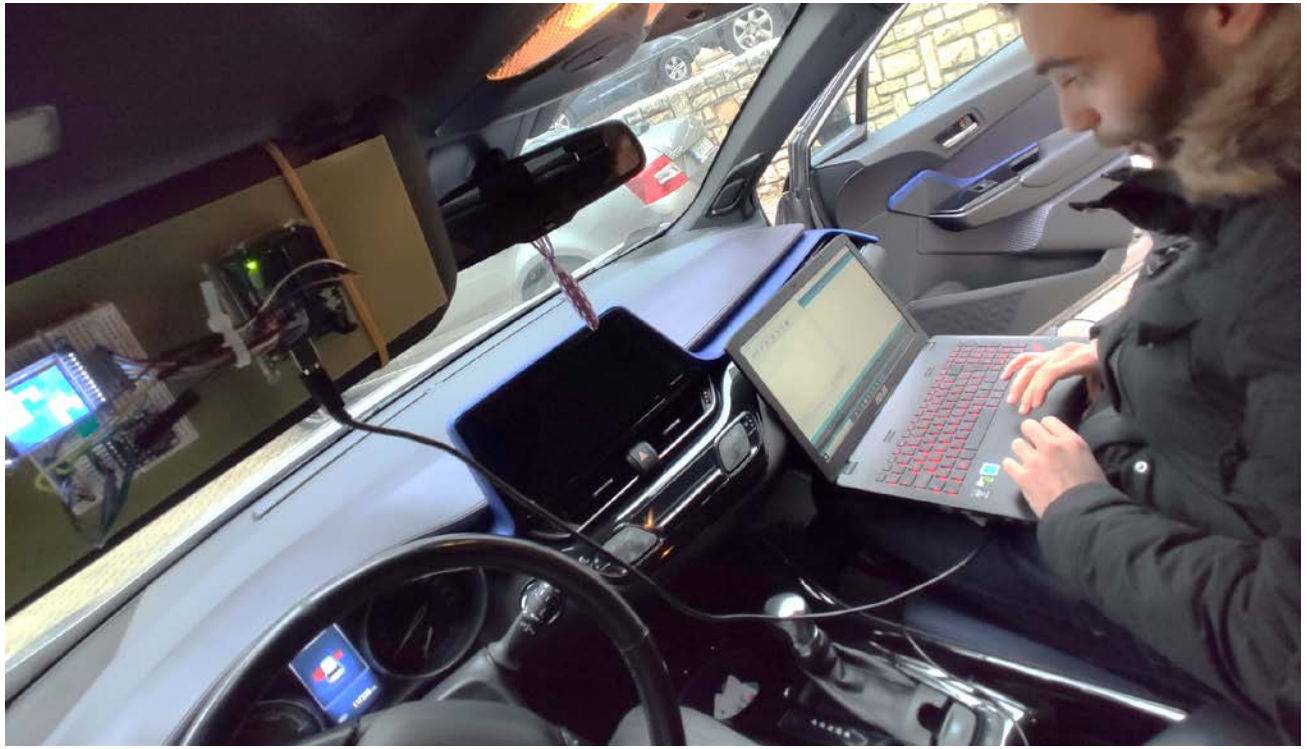
FURTHER APPLICATIONS OF GRID EYE AT BME-ETT



Passenger detection in cars.

1	1,5	1,25	2,25	3,25	4	2,75	2,5
1,25	1,5	2	13,75	13,25	7,75	1,75	1,5
1,5	1	3	14,25	14,5	12	1,25	1
1,75	1,5	5,75	15,5	15,25	10,5	1	0,75
2	2,5	5,25	10,25	10	5,5	2,25	1,25
2,25	3	3,75	4	5,5	3,5	2	1,25
3,25	2,75	2,5	2,75	3	2,75	1,5	0,25
2,75	3	2,25	2	2,25	1,75	0,5	1

Left: *Seated passenger*

-0,25	-0,75	-0,25	0,5	-0,75	-0,5	-0,75	-1
0	-0,5	-1,25	-0,75	1,25	0,25	-1,5	-1
0,5	-1,25	-1	-0,25	1,25	1	-0,5	-1,25
-0,25	0	0	0	0,25	0,25	-0,75	-1,5
0,25	0,5	-0,5	0,5	0,5	0,25	-1	-0,5
0	0,75	3	4,25	5,25	4,5	2,5	1,5
0,5	-0,5	4,25	5,75	5,75	6	3,25	1,25
-0,25	0,75	6	6	6	6,25	4	1,5

Right: *Empty seat after driving*

Test during wintertime.

Ricardo de Jorge Melgar - Investigations on IR Sensors For Detecting People In a Car, BSc Thesis

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CONCLUSIONS:

The presented Grid-Eye application offers HMI and OSH functionality extension in the mindset of Industry 4.0, for reflow soldering.

With the applied sensor and control box, it is possible to differentiate the oven, the PCB holder (with possible PCBA load in alignment with the cells in the grid) and any obtrusion larger than a cell (e.g. an approaching cold hand).

FUTURE?

- Industry4.0 readiness?
- IoT readiness?
- Additional sensors?
- Mobile application integration for complete reflow monitoring?

Safer work and immediate feedback on the state of the process.

ACKNOWLEDGEMENT: The applied sensor research is supported by the National Research, Development and Innovation Fund (TUDFO/51757/2019-ITM) Thematic Excellence Program.