Vrijednost stvarnovremenskih podataka s polja za poljoprivredu: poljski pokusi u 2023. godini

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European Union
together to EU funds

EUROPEAN STRUCTURAL AND INVESTMENT FUNDS

Operativni program KONKURENTNOST I KOHEZIJA
Operational Programme Competitiveness and cohesion

REPUBLIC OF CROATIA
Ministry of Science and Education

The project "IoT-field: An Ecosystem of Networked Devices and Services for IoT Solutions Applied in Agriculture" is co-financed by the European Union from the European Regional Development Fund within the Operational programme Competitiveness and Cohesion 2014-2020 of the Republic of Croatia

Motvacija

- State-of-the-art: prikupljanje podataka na kraju sezone: žetva
- Stvarnovremeni podaci = **podaci koji se prikupljaju i obrađuju u trenutku njihovog nastanka ili u vrlo kratkom vremenskom razdoblju**.
- Poljoprivreda -> sektor izložen brojnim izazovima i rizicima
  - klimatske promjene
  - tržišna nestabilnost
  - konkurentnost
  - zaštita okoliša
  - sigurnost hrane

Podaci

- Stvarnovremeni podaci u poljoprivredi:
  - Podaci o **vremenskim uvjetima i klimatskim promjenama:**
    - **mogu pomoći u predviđanju i prilagodbi** utjecaja klimatskih promjena na poljoprivredu te u optimizaciji korištenja vode i energije.
  - **Podaci o stanju tla i biljaka**
    - **Praćenje plodnosti tla, potreba za gnojidbom i navodnjavanjem**, prisutnosti bolesti i štetnika te učinka različitih **agrotehničkih mjera**.
  - Podaci o životinjskoj proizvodnji koji se mogu prikupljati putem elektroničkih markica, čipova ili drugih uređaja koji se postavljaju na životinje ili u njihovoj blizini
    - Mogu pomoći u praćenju zdravlja, rasta, reprodukcije i dobrobiti životinja te u upravljanju stajskim otpadom i emisijama stakleničkih plinova.
  - Podaci o tržištu i potrošnji
    - Mogu se prikupljati putem interneta, mobilnih aplikacija ili drugih kanala komunikacije. Mogu pomoći u praćenju ponude i potražnje za poljoprivrednim proizvodima, cijena, kvalitete, preferencija potrošača te u usklađivanju proizvodnje s tržišnim potrebama.

Podaci

- Za korištenje stvarnovremenih podataka potrebno je osigurati njihovu **dostupnost, kvalitetu, sigurnost i zaštitu** te razviti odgovarajuće **vještine i kapacitete** poljoprivrednika i drugih dionika u poljoprivrednom sektoru.

Blizinsko (proksimalno) motrenje usjeva

- Proksimalno multispektralno motrenje može omogućiti **preciznu procjenu stanja usjeva** i njihovog **rasta i razvoja** na temelju **spektralnih svojstava** biljaka
- Proksimalno multispektralno motrenje može otkriti **rane znakove stresa**, **bolesti, štetnika ili nedostatka hranjiva** kod usjeva i omogućiti pravovremenu **intervenciju i tretman**
- Proksimalno multispektralno motrenje može pomoći **u optimizaciji korištenja vode, gnojiva, pesticida i drugih resursa** za uzgoj usjeva te smanjiti negativne utjecaje na okoliš
- Proksimalno multispektralno motrenje može **povećati kvalitetu i količinu prinosa žitarica** te poboljšati njihovu **tržišnu vrijednost**

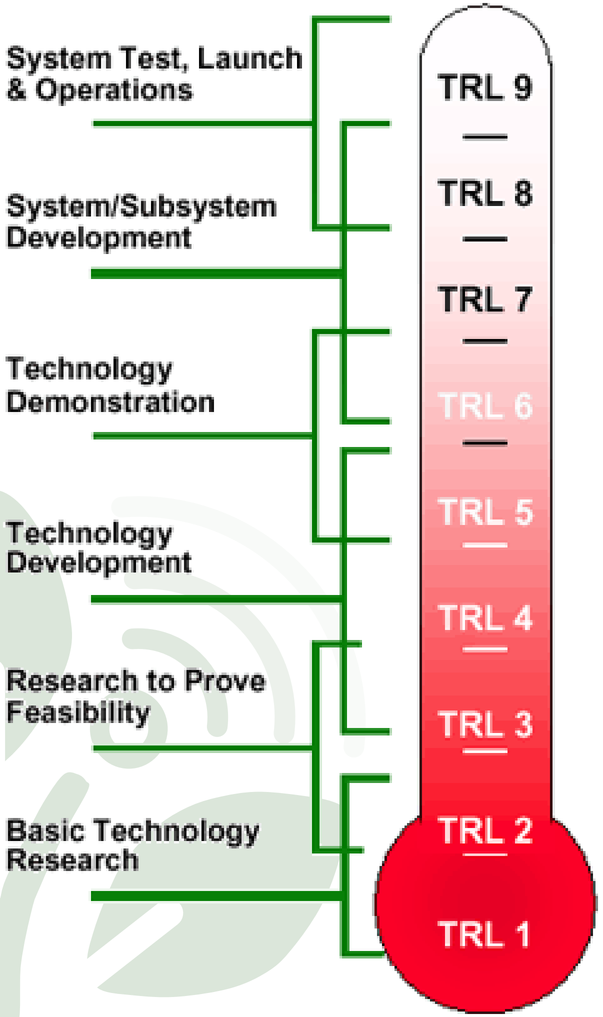
Prednosti pristupa

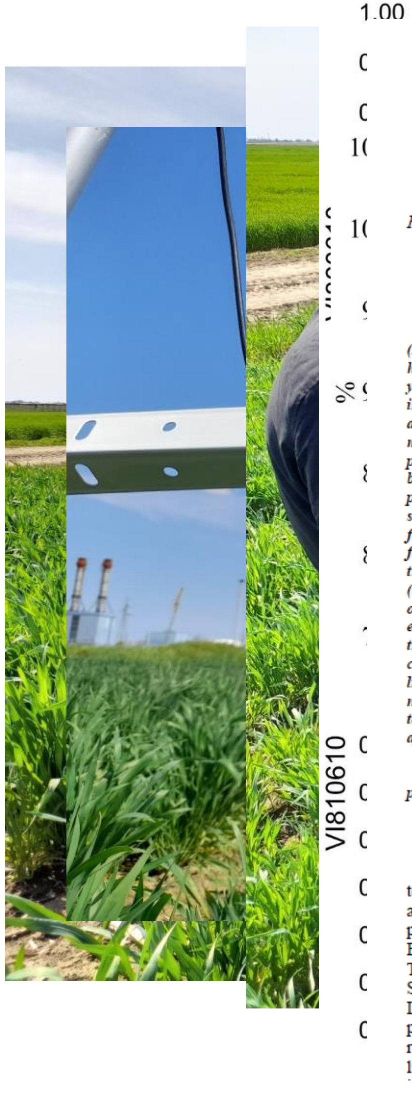
- Proksimalni multispektralni senzor je senzor koji se nalazi **u blizini površine** koju snima i koristi **više spektralnih kanala** za otkrivanje radijacije unutar uskih raspona valnih duljina
- Takav senzor može pružiti visoku **temporalnu i spektralnu rezoluciju** podataka o **stanju tla, biljaka i okoliša**, kao i o funkcionalnosti biljaka na temelju spektralnih svojstava
- Može **kontinuirano pratiti promjene na polju i usjevima** tijekom cijele vegetacije i omogućiti **brzu reakciju i prilagodbu** poljoprivrednih mjera
- = cjelovito IoT-rješenje koje uključuje pouzdan **prijenos i pohranu podataka, obradu i analizu podataka te aplikaciju za interakciju s korisnikom**

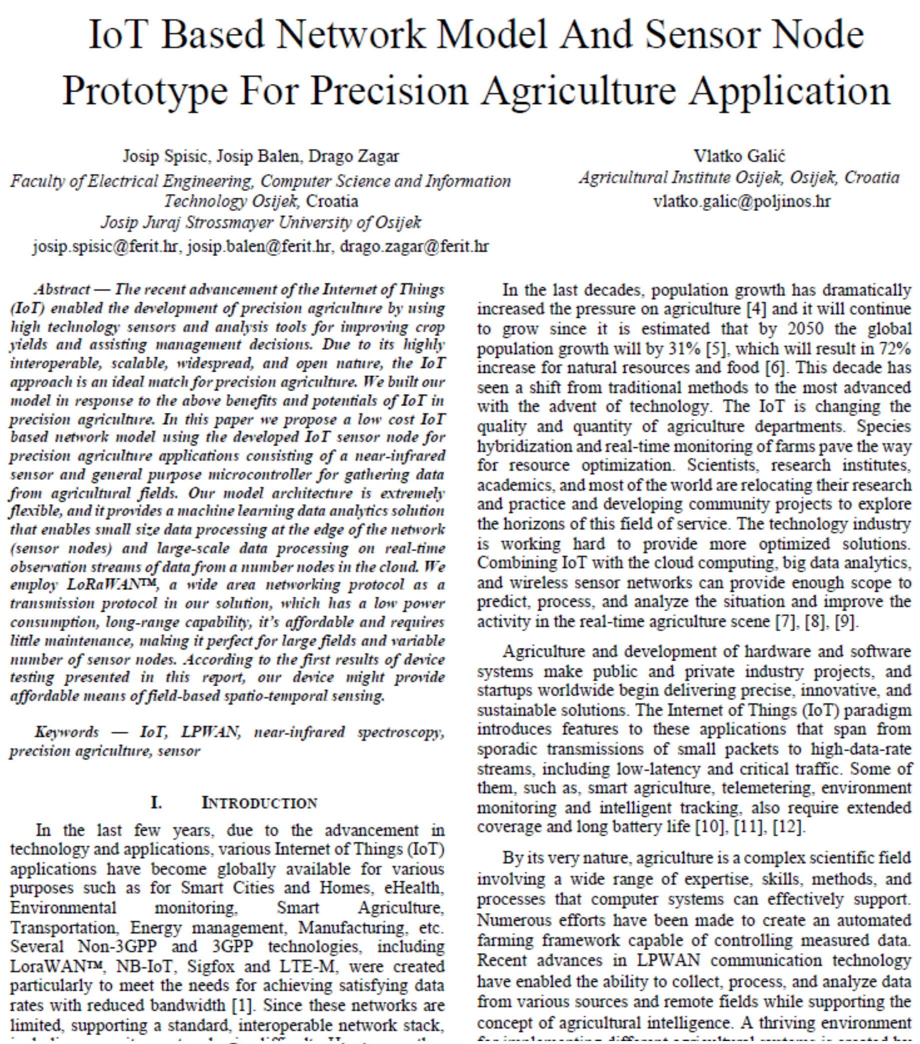
Nedostaci pristupa

- Proksimalni multispektralni senzor zahtijeva **složenu i skupu tehnologiju izrade**, kao što su mikroelektromehanička tehnologija ili nanotehnologija
- Takav senzor može biti **osjetljiv na atmosferske utjecaje**, kao što su oblaci, magla, prašina ili dim, koji mogu utjecati na kvalitetu i točnost podataka
- Takav senzor može imati **ograničen domet i pokrivenost područja** što može biti problem za velike površine ili nepristupačne terene
- Takav senzor može zahtijevati **visoku potrošnju energije i održavanje**, što može povećati troškove i smanjiti pouzdanost sustava

TRL 3 - 2021







IoT Based Network Model And Sensor Node Prototype For Precision Agriculture Application

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Abstract — *The recent advancement of the Internet of Things (IoT) enabled the development of precision agriculture by using high technology sensors and analysis tools for improving crop yields and assisting management decisions. Due to its highly interoperable, scalable, widespread, and open nature, the IoT approach is an ideal match for precision agriculture. We built our model in response to the above benefits and potentials of IoT in precision agriculture. In this paper we propose a low cost IoT based network model using the developed IoT sensor node for precision agriculture applications consisting of a near-infrared sensor and general purpose microcontroller for gathering data from agricultural fields. Our model architecture is extremely flexible, and it provides a machine learning data analytics solution that enables small size data processing at the edge of the network (sensor nodes) and large-scale data processing on real-time observation streams of data from a number nodes in the cloud. We employ LoRaWAN™, a wide area networking protocol as a transmission protocol in our solution, which has a low power consumption, long-range capability, it's affordable and requires little maintenance, making it perfect for large fields and variable number of sensor nodes. According to the first results of device testing presented in this report, our device might provide affordable means of field-based spatio-temporal sensing.*

Keywords — *IoT, LPWAN, near-infrared spectroscopy, precision agriculture, sensor*

I. Introduction

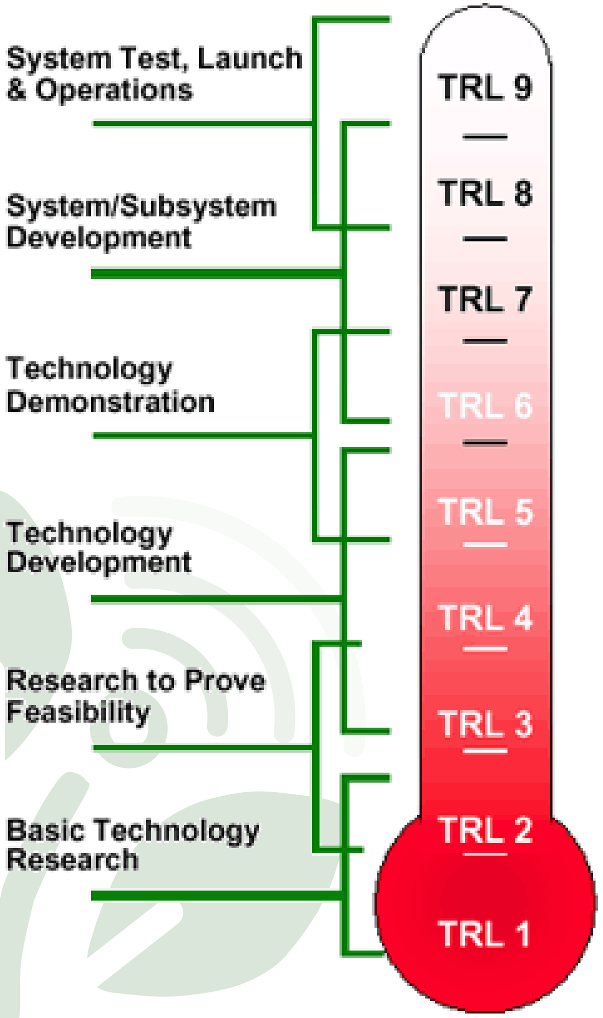
In the last few years, due to the advancement in technology and applications, various Internet of Things (IoT) applications have become globally available for various purposes such as for Smart Cities and Homes, eHealth, Environmental monitoring, Smart Agriculture, Transportation, Energy management, Manufacturing, etc. Several Non-3GPP and 3GPP technologies, including LoraWAN™, NB-IoT, Sigfox and LTE-M, were created particularly to meet the needs for achieving satisfying data rates with reduced bandwidth [1]. Since these networks are limited, supporting a standard, interoperable network stack,

In the last decades, population growth has dramatically increased the pressure on agriculture [4] and it will continue to grow since it is estimated that by 2050 the global population growth will by 31% [5], which will result in 72% increase for natural resources and food [6]. This decade has seen a shift from traditional methods to the most advanced with the advent of technology. The IoT is changing the quality and quantity of agriculture departments. Species hybridization and real-time monitoring of farms pave the way for resource optimization. Scientists, research institutes, academics, and most of the world are relocating their research and practice and developing community projects to explore the horizons of this field of service. The technology industry is working hard to provide more optimized solutions. Combining IoT with the cloud computing, big data analytics, and wireless sensor networks can provide enough scope to predict, process, and analyze the situation and improve the activity in the real-time agriculture scene [7], [8], [9].

Agriculture and development of hardware and software systems make public and private industry projects, and startups worldwide begin delivering precise, innovative, and sustainable solutions. The Internet of Things (IoT) paradigm introduces features to these applications that span from sporadic transmissions of small packets to high-data-rate streams, including low-latency and critical traffic. Some of them, such as, smart agriculture, telemetering, environment monitoring and intelligent tracking, also require extended coverage and long battery life [10], [11], [12].

By its very nature, agriculture is a complex scientific field involving a wide range of expertise, skills, methods, and processes that computer systems can effectively support. Numerous efforts have been made to create an automated farming framework capable of controlling measured data. Recent advances in LPWAN communication technology have enabled the ability to collect, process, and analyze data from various sources and remote fields while supporting the concept of agricultural intelligence. A thriving environment

TRL 3.9 – 2021.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Basic Technology Research
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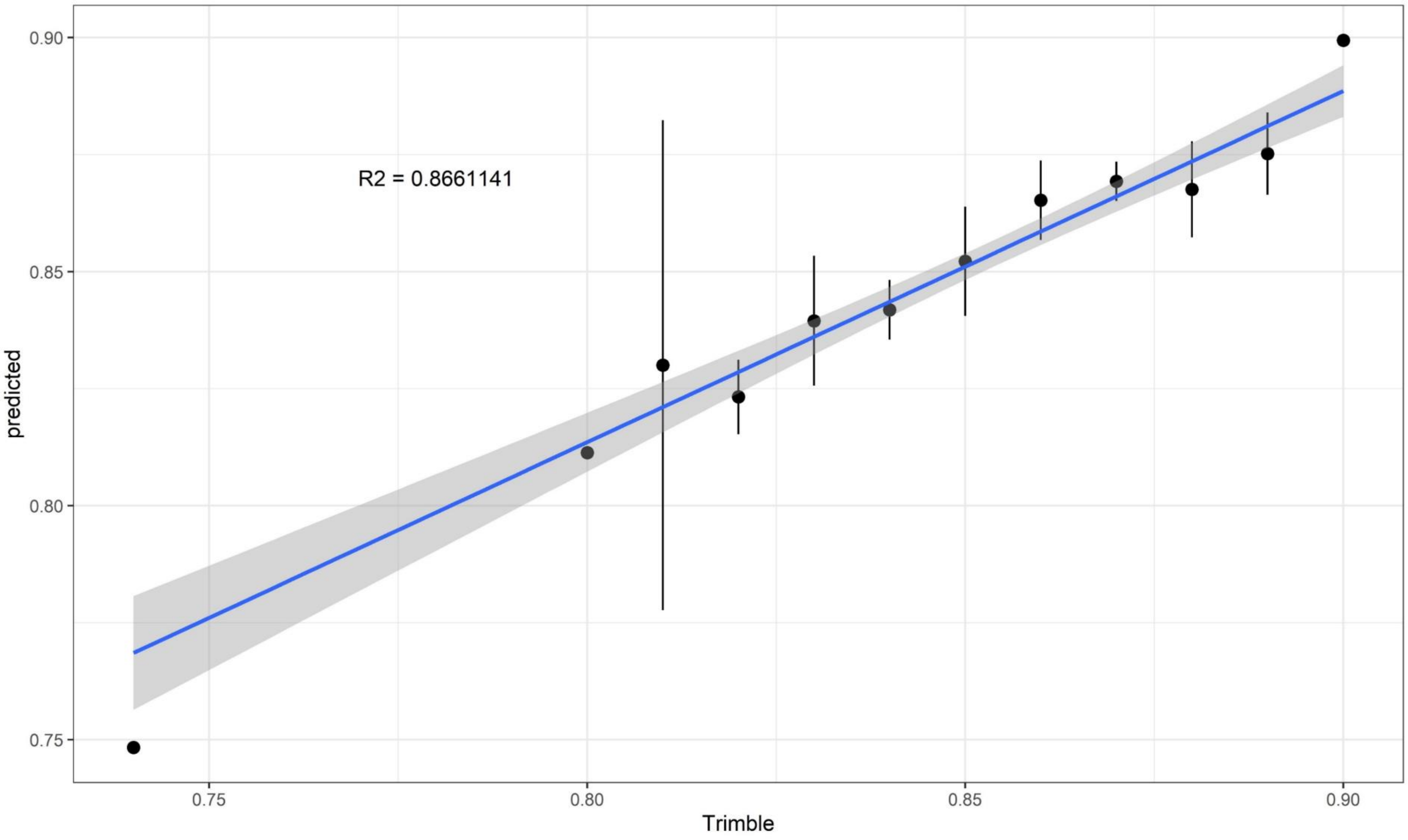
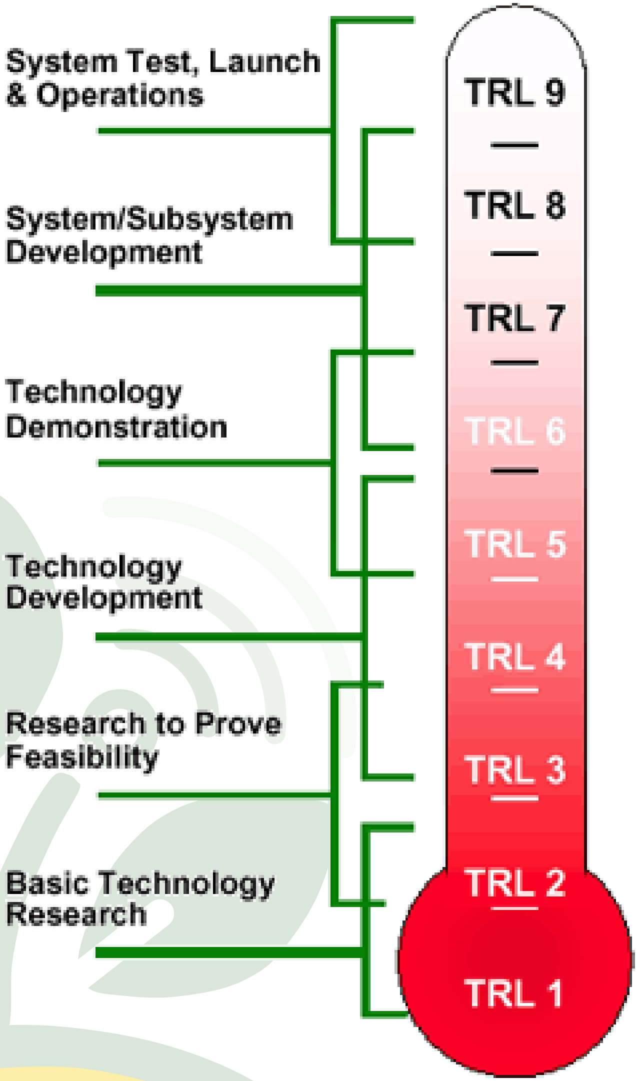
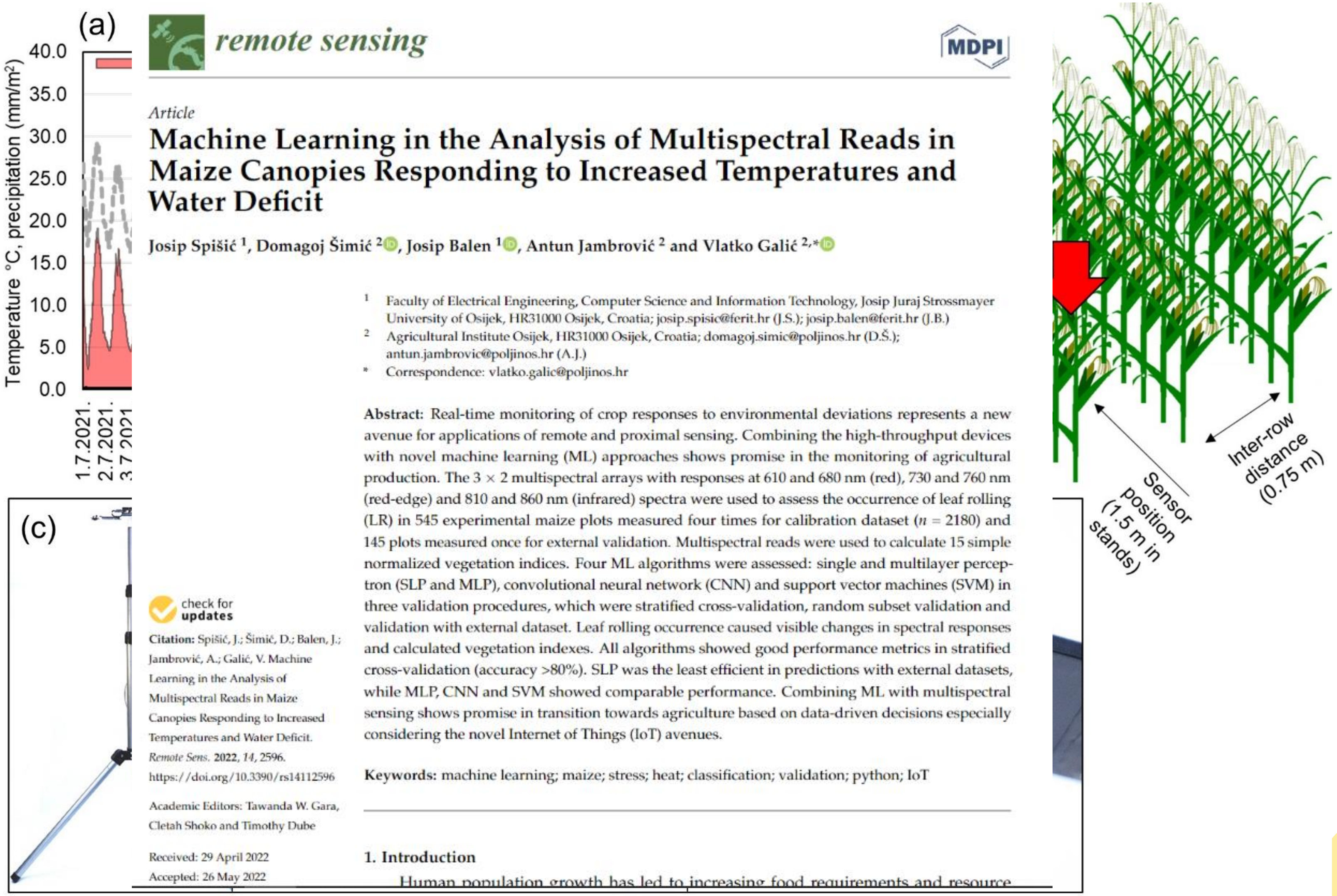

R2 = 0.8661141
predicted
Trimble
0.75
0.80
0.85
0.90

TRL 4, kasnije 2021.





remote sensing

MDPI

Article

Machine Learning in the Analysis of Multispectral Reads in Maize Canopies Responding to Increased Temperatures and Water Deficit

Josip Spišić [1], Domagoj Šimić [2], Josip Balen [1], Antun Jambrović [2] and Vlatko Galić [2,*]

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[2] Agricultural Institute Osijek, HR31000 Osijek, Croatia; domagoj.simic@poljinos.hr (D.Š.); antun.jambrovic@poljinos.hr (A.J.)
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Abstract: Real-time monitoring of crop responses to environmental deviations represents a new avenue for applications of remote and proximal sensing. Combining the high-throughput devices with novel machine learning (ML) approaches shows promise in the monitoring of agricultural production. The 3 × 2 multispectral arrays with responses at 610 and 680 nm (red), 730 and 760 nm (red-edge) and 810 and 860 nm (infrared) spectra were used to assess the occurrence of leaf rolling (LR) in 545 experimental maize plots measured four times for calibration dataset (n = 2180) and 145 plots measured once for external validation. Multispectral reads were used to calculate 15 simple normalized vegetation indices. Four ML algorithms were assessed: single and multilayer perceptron (SLP and MLP), convolutional neural network (CNN) and support vector machines (SVM) in three validation procedures, which were stratified cross-validation, random subset validation and validation with external dataset. Leaf rolling occurrence caused visible changes in spectral responses and calculated vegetation indexes. All algorithms showed good performance metrics in stratified cross-validation (accuracy >80%). SLP was the least efficient in predictions with external datasets, while MLP, CNN and SVM showed comparable performance. Combining ML with multispectral sensing shows promise in transition towards agriculture based on data-driven decisions especially considering the novel Internet of Things (IoT) avenues.

Keywords: machine learning; maize; stress; heat; classification; validation; python; IoT

check for updates

Citation: Spišić, J.; Šimić, D.; Balen, J.; Jambrović, A.; Galić, V. Machine Learning in the Analysis of Multispectral Reads in Maize Canopies Responding to Increased Temperatures and Water Deficit. *Remote Sens.* **2022**, *14*, 2596. https://doi.org/10.3390/rs14112596

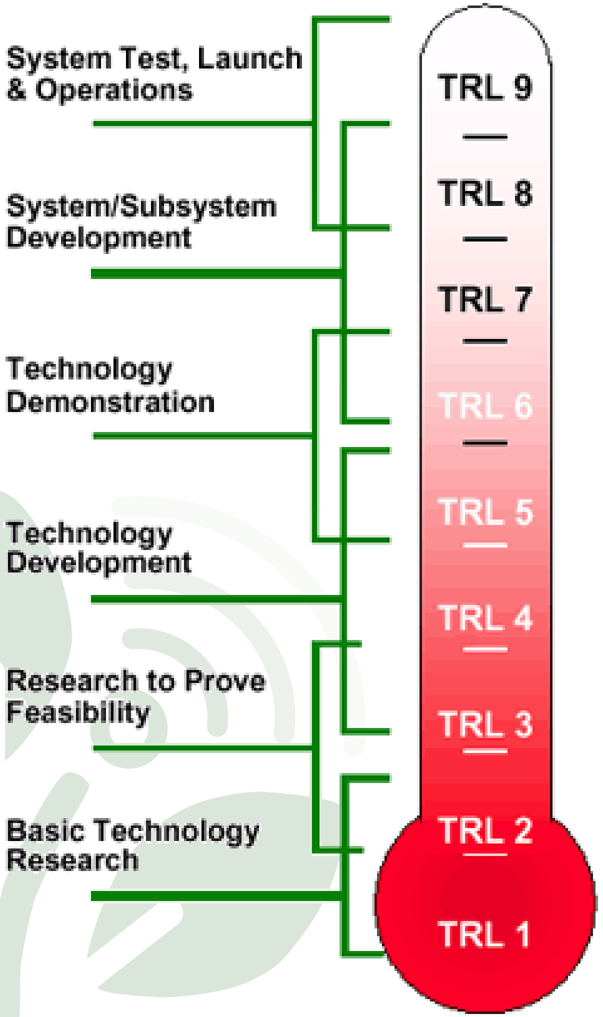
Academic Editors: Tawanda W. Gara, Cletah Shoko and Timothy Dube

Received: 29 April 2022
Accepted: 26 May 2022

1. Introduction

Human population growth has led to increasing food requirements and resource

TRL 5 2022.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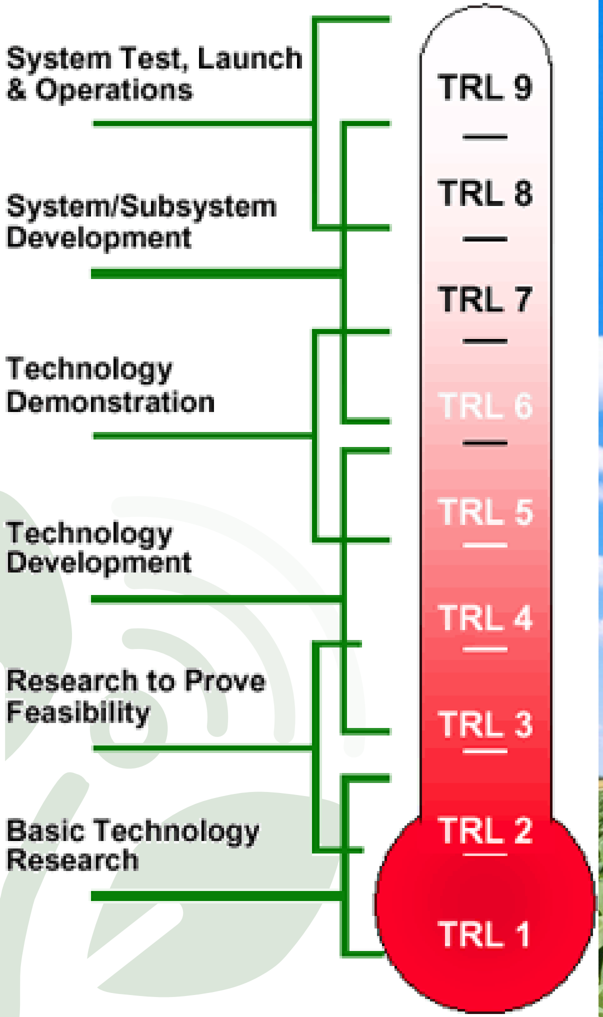
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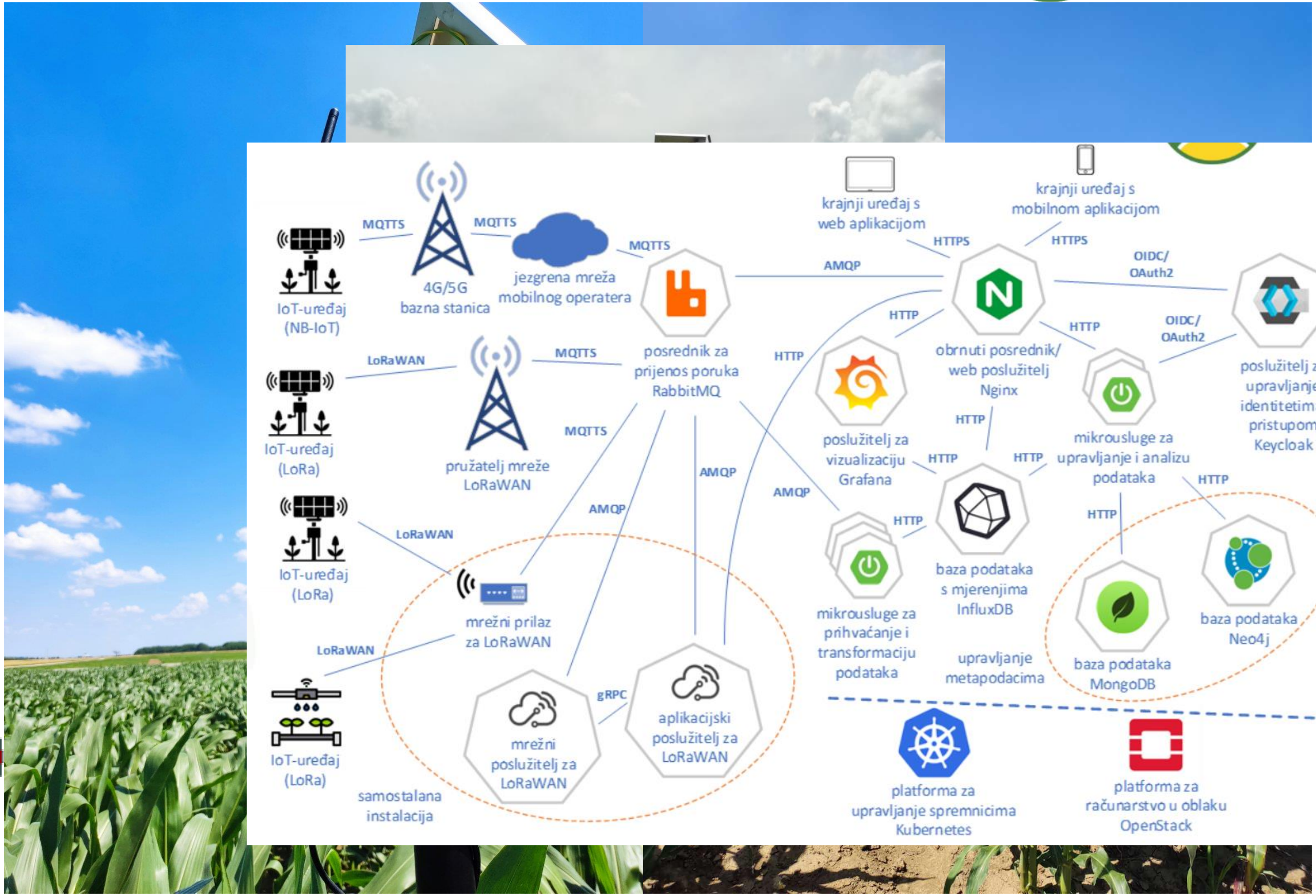
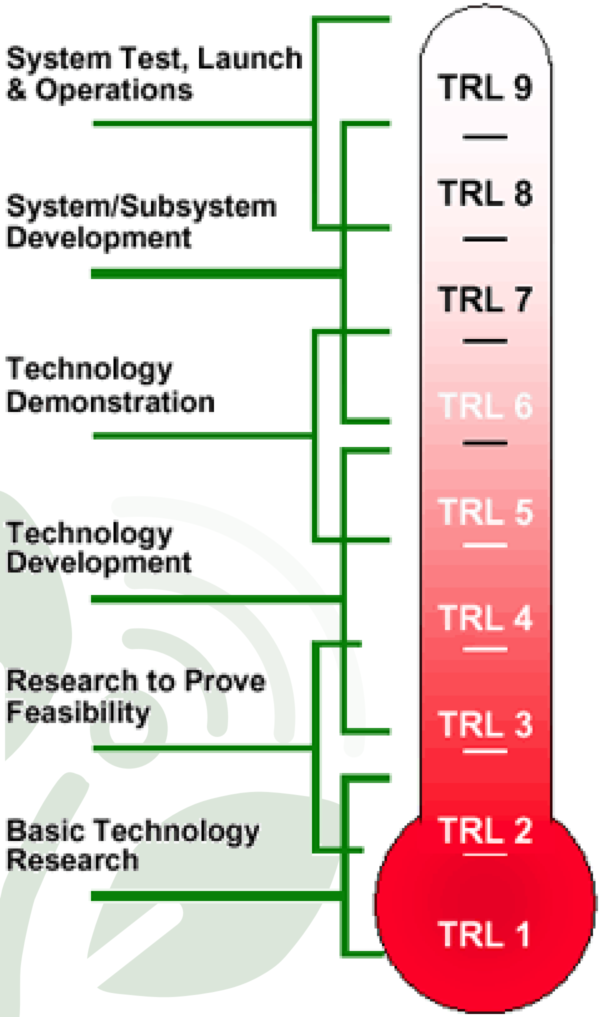
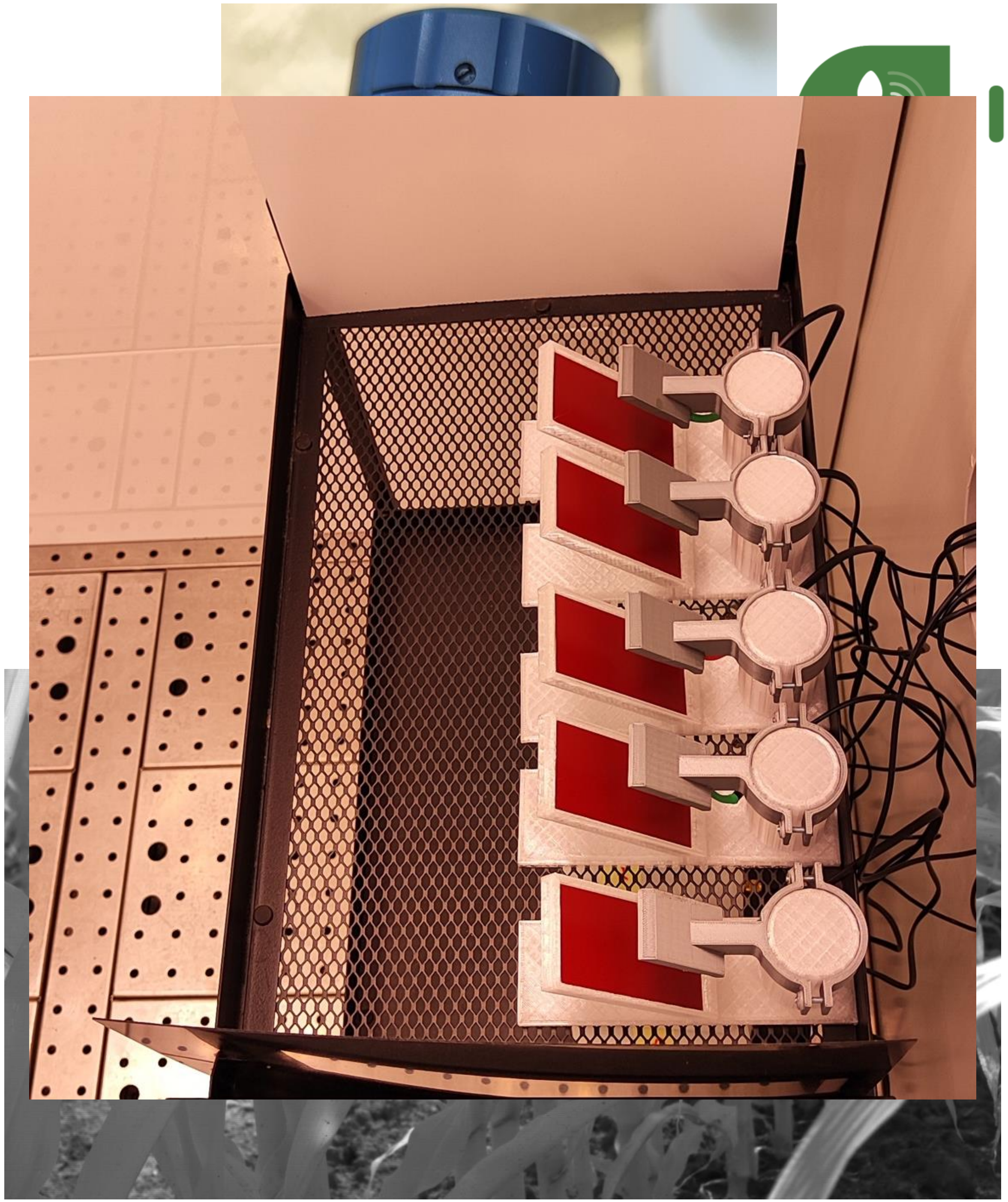

IoT-uređaj (NB-IoT)
MQTTS
4G/5G bazna stanica
MQTTS
jezgrena mreža mobilnog operatera
MQTTS
posrednik za prijenos poruka RabbitMQ
AMQP
krajnji uređaj s web aplikacijom
HTTPS
krajnji uređaj s mobilnom aplikacijom
HTTPS
obrnuti posrednik/ web poslužitelj Nginx
OIDC/ OAuth2
poslužitelj za upravljanje identitetima i pristupom Keycloak
IoT-uređaj (LoRa)
LoRaWAN
pružatelj mreže LoRaWAN
MQTTS
HTTP
poslužitelj za vizualizaciju Grafana
mikrousluge za upravljanje i analizu podataka
baza podataka s mjerenjima InfluxDB
mikrousluge za prihvaćanje i transformaciju podataka
upravljanje metapodacima
baza podataka MongoDB
baza podataka Neo4j
AMQP
mrežni prilaz za LoRaWAN
mrežni poslužitelj za LoRaWAN
gRPC
aplikacijski poslužitelj za LoRaWAN
samostalana instalacija
platforma za upravljanje spremnicima Kubernetes
platforma za računarstvo u oblaku OpenStack

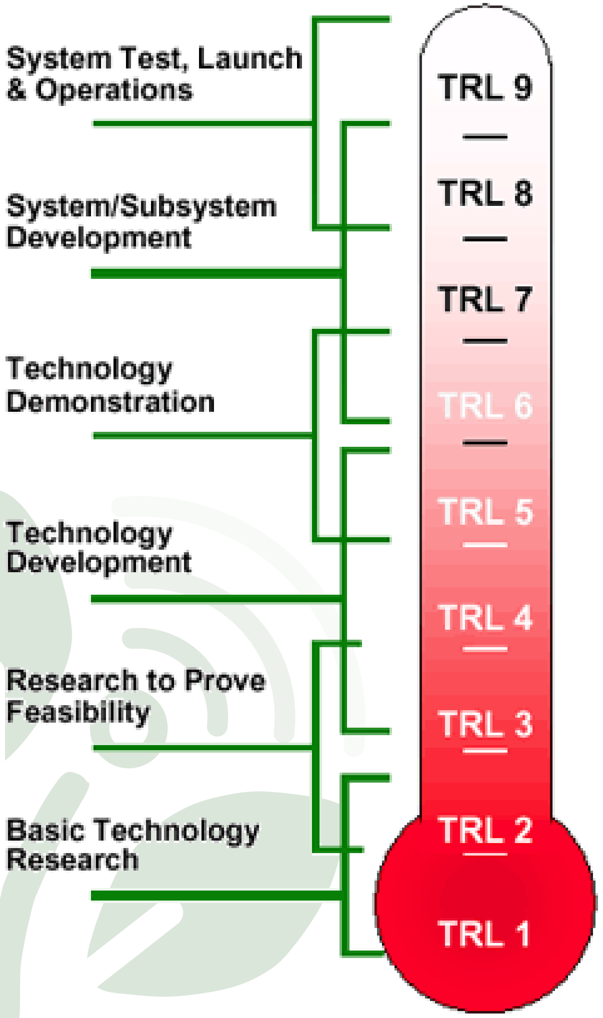
TRL 5.5 2023.

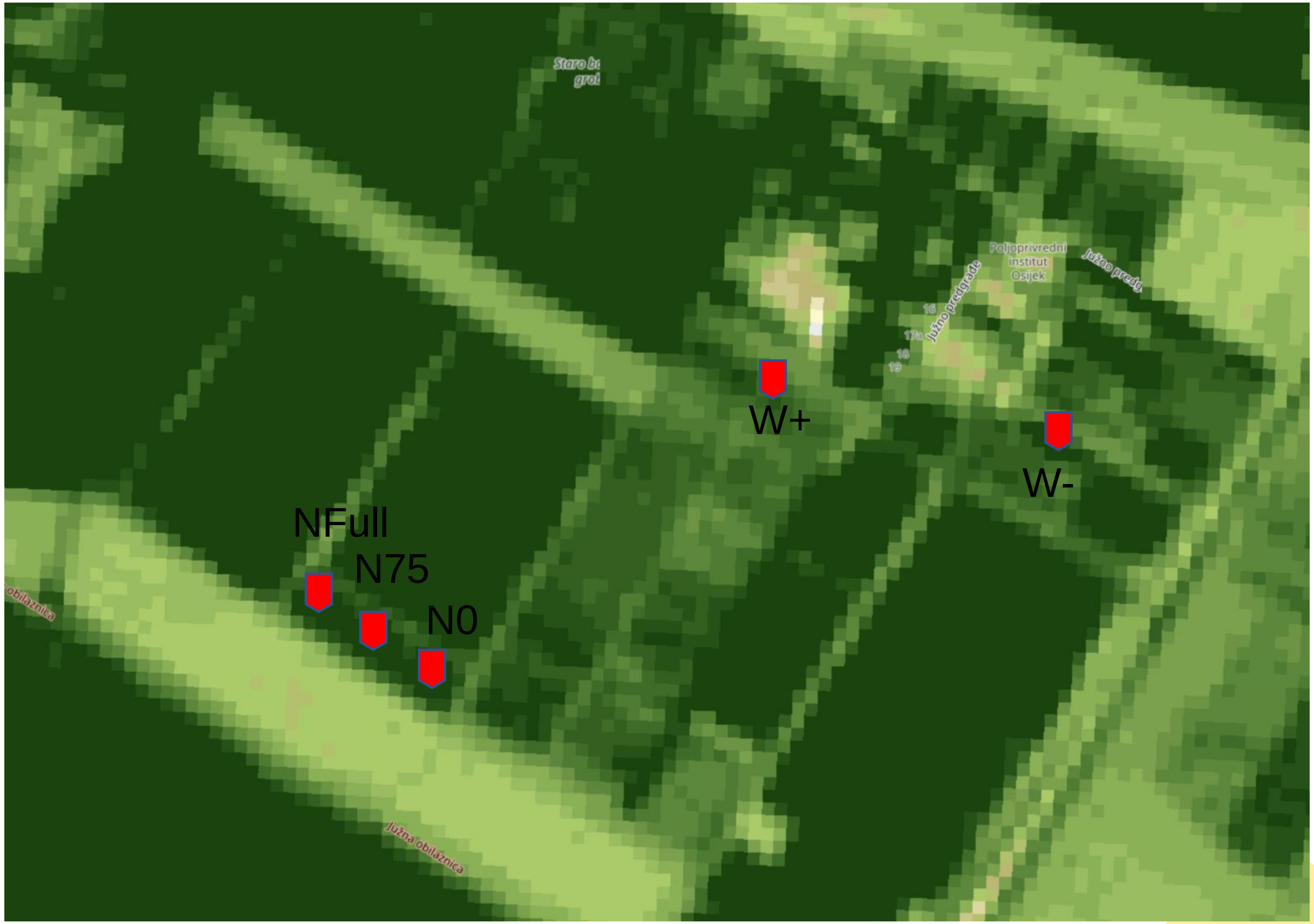




IoT-field

TRL 5.5, pokusi 2023.





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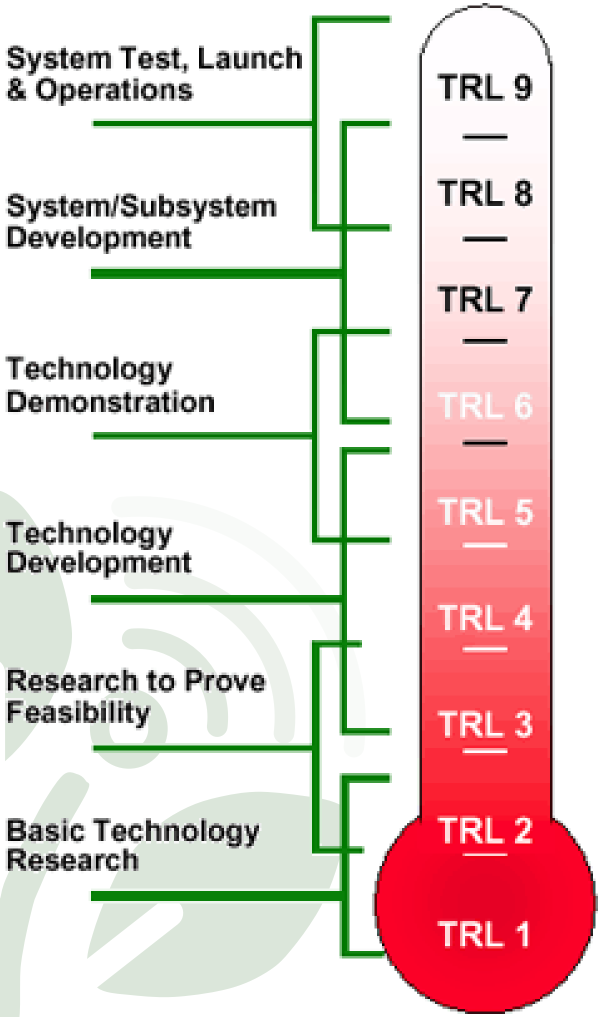
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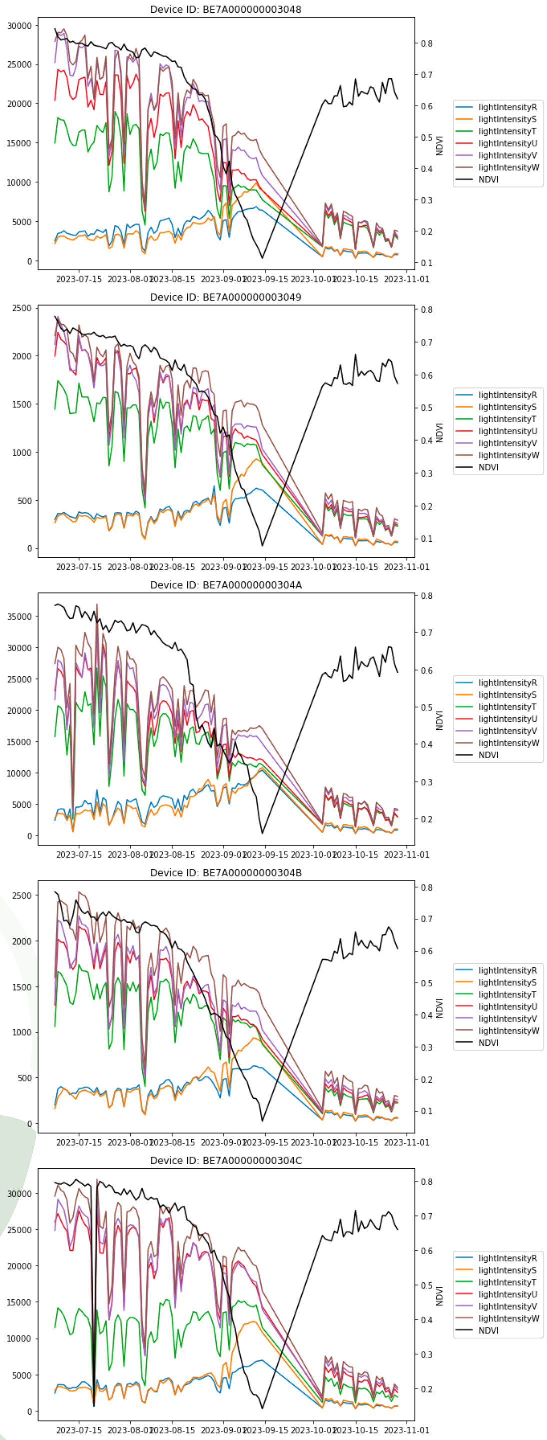
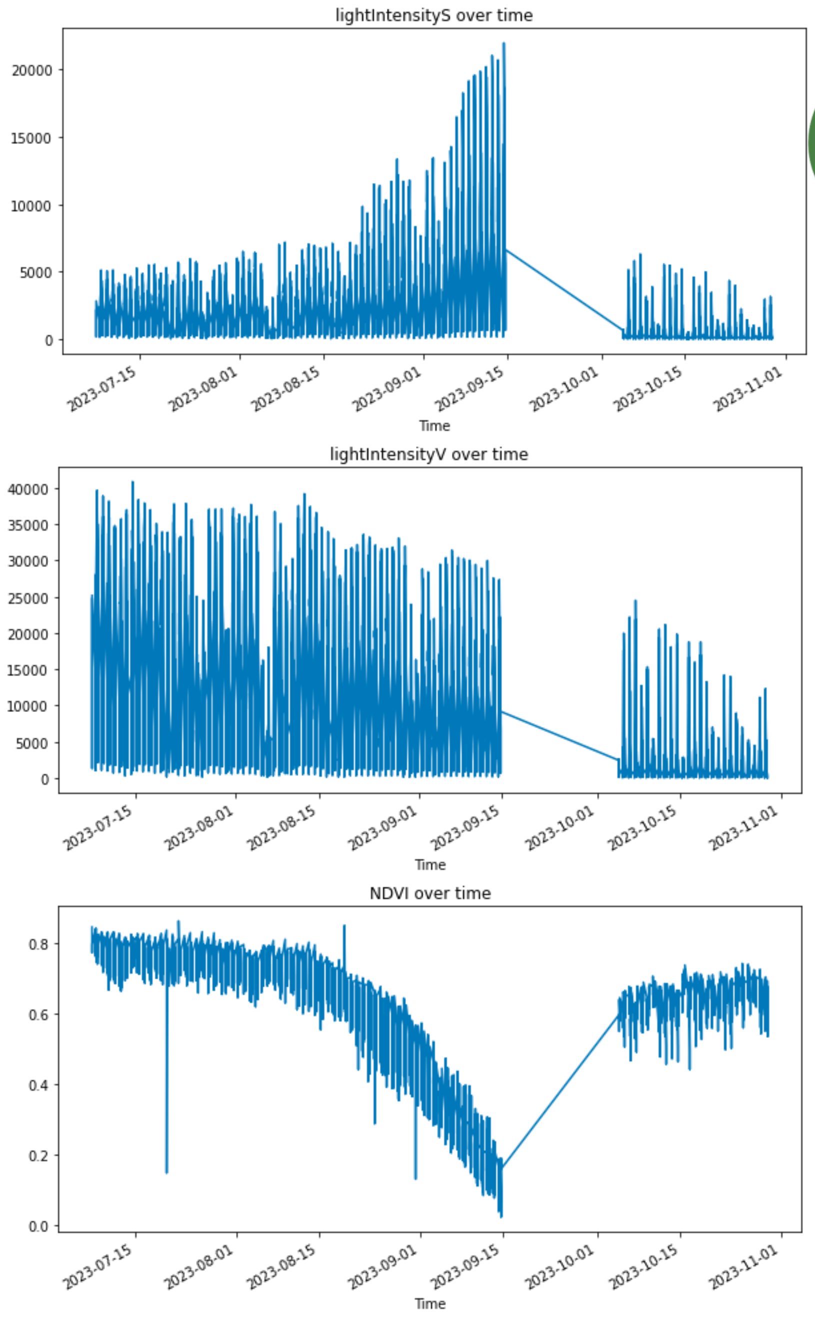
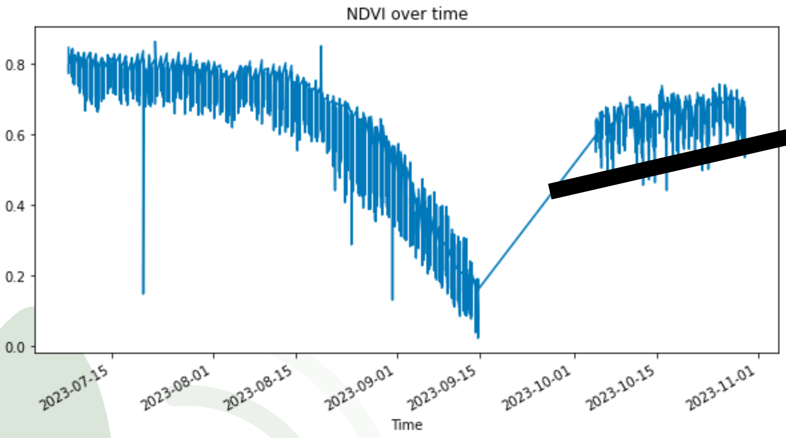

Device ID: BE7A000000003048
Device ID: BE7A000000003049
Device ID: BE7A00000000304A
Device ID: BE7A00000000304B
Device ID: BE7A00000000304C
lightIntensityR
lightIntensityS
lightIntensityT
lightIntensityU
lightIntensityV
lightIntensityW
NDVI


lightIntensityS over time
lightIntensityV over time
NDVI over time
Time

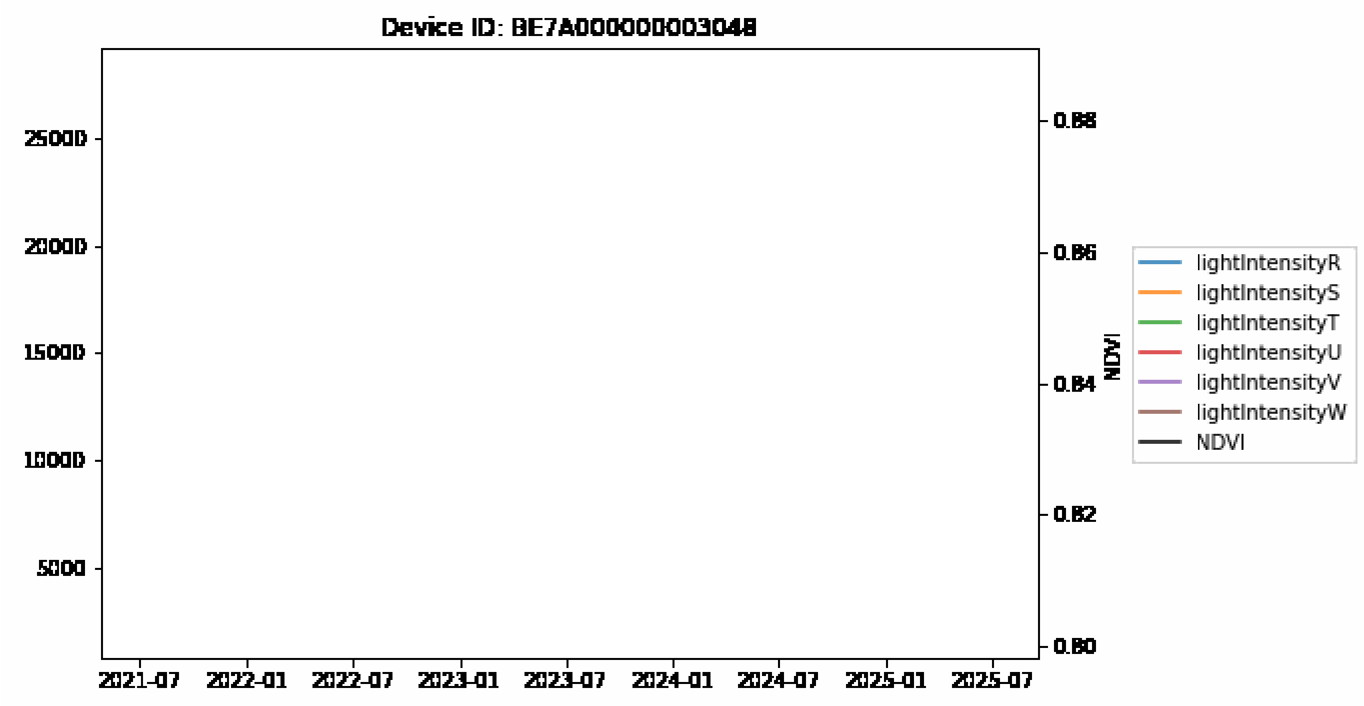
- NDVI = (V-S)/(V+S)

IoT-field

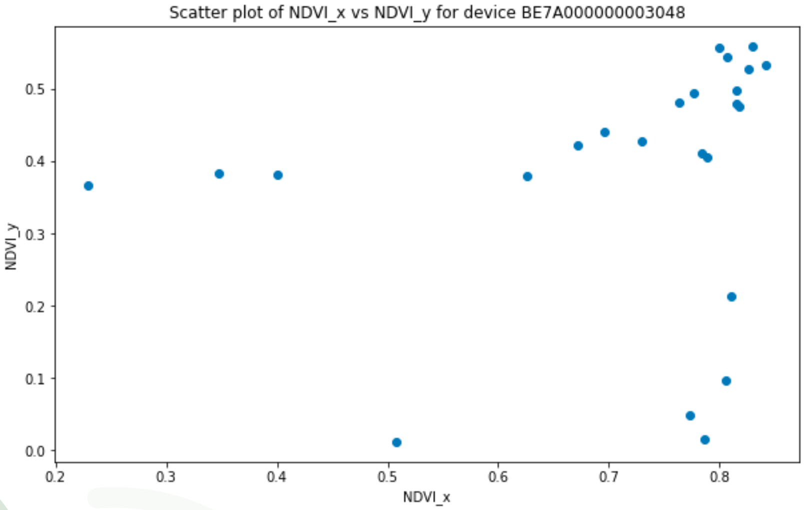

NDVI over time
0.8
0.6
0.4
0.2
0.0
2023-07-15
2023-08-01
2023-08-15
2023-09-01
2023-09-15
2023-10-01
2023-10-15
2023-11-01
Time

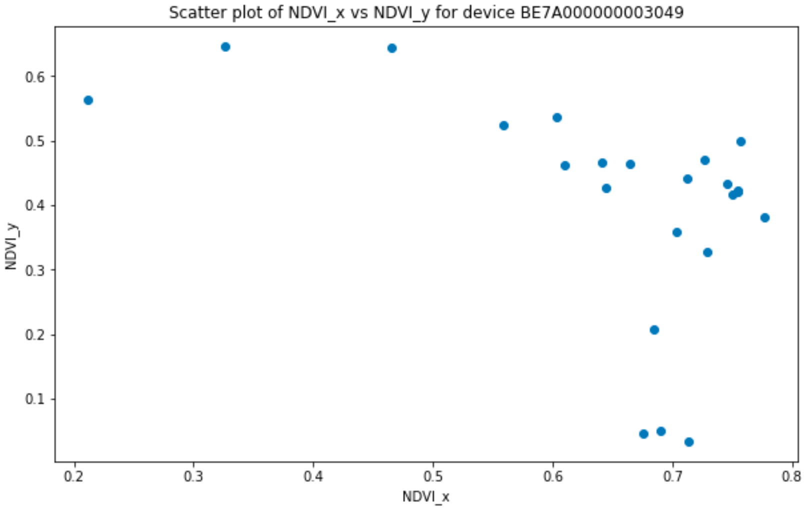
Satelitski podaci visoke prostorne rezolucije (10m)

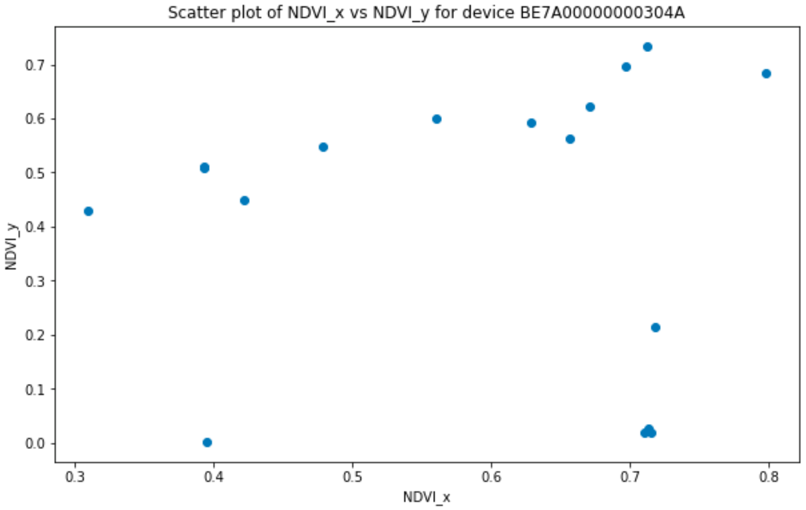
Komplementiranje prostorne I vremenske rezolucije

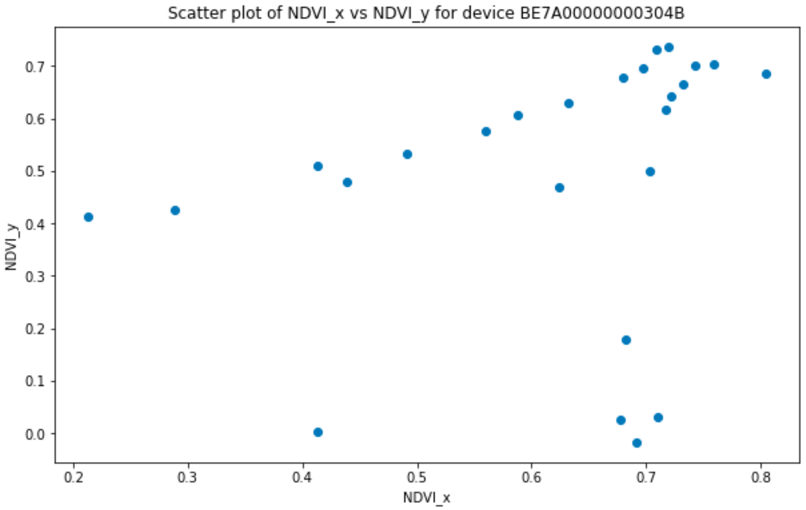


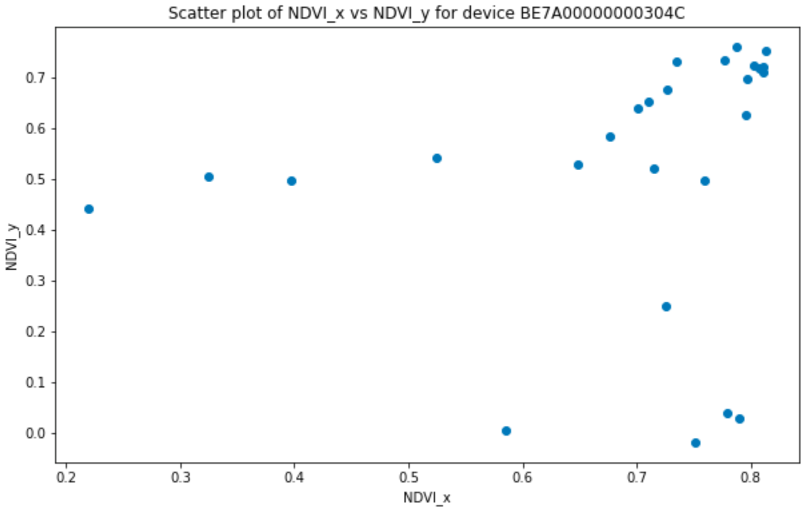
2023 – Sentinel (y) vs IoT-field (x)



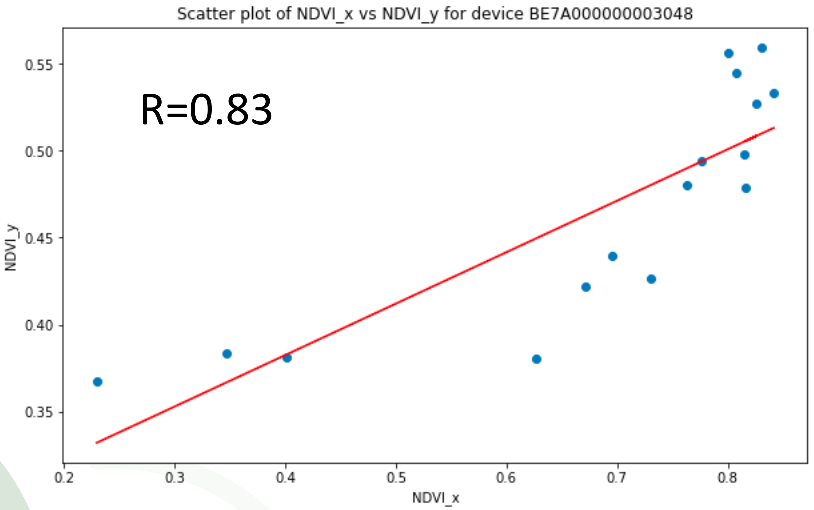


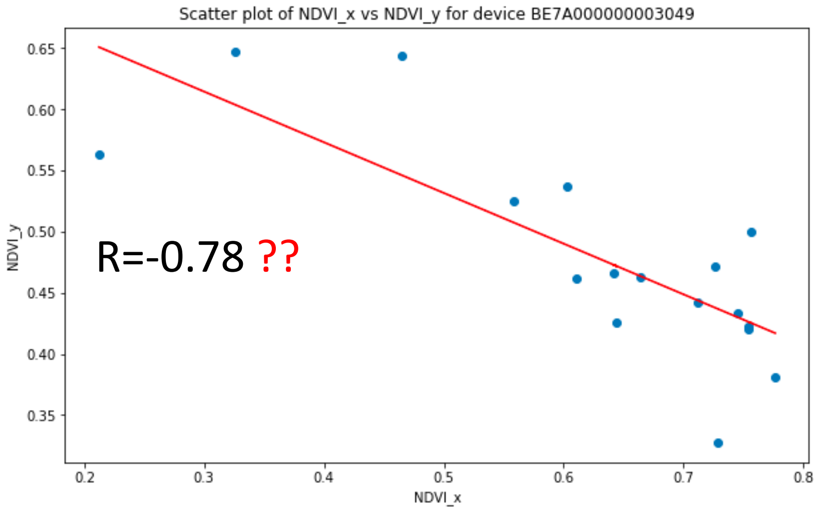


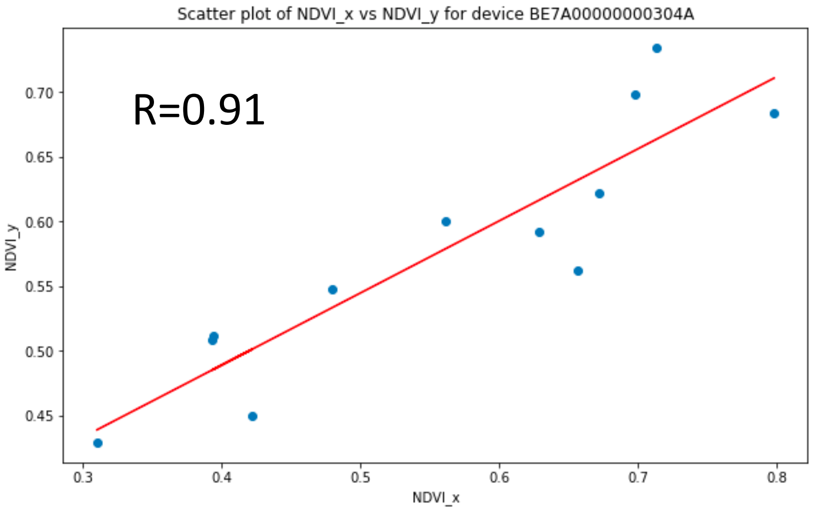


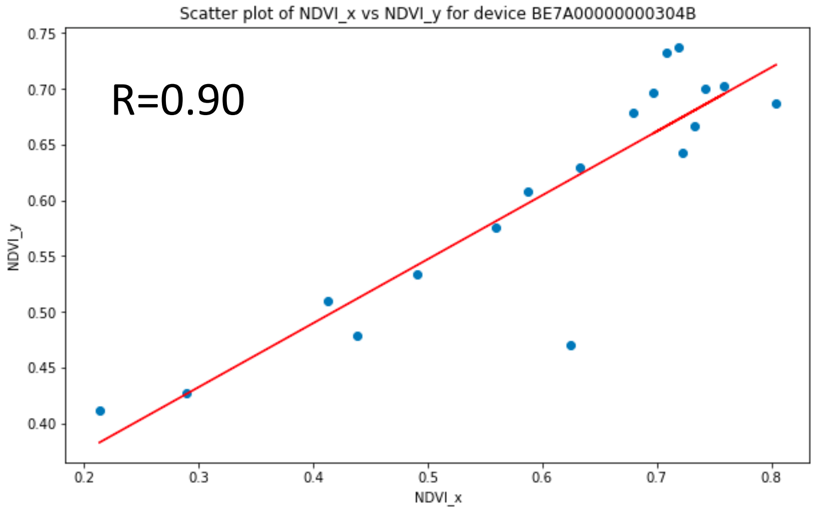


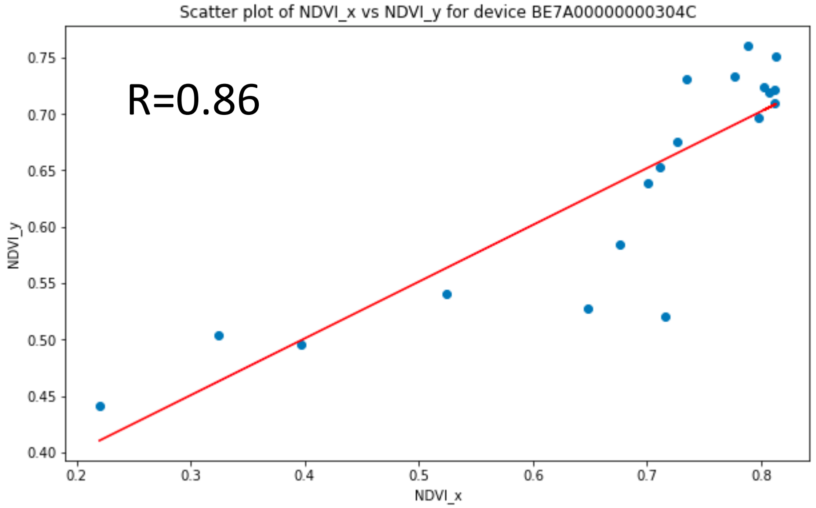
2023 – cloud coverage <10%



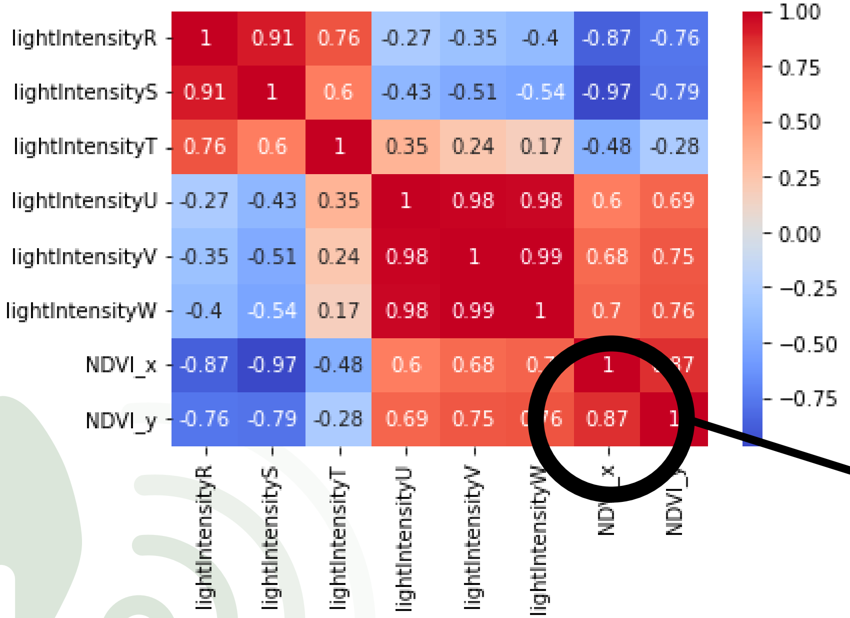








2023



lightIntensityR
lightIntensityS
lightIntensityT
lightIntensityU
lightIntensityV
lightIntensityW
NDVI_x
NDVI_y
1 0.91 0.76 -0.27 -0.35 -0.4 -0.87 -0.76
0.91 1 0.6 -0.43 -0.51 -0.54 -0.97 -0.79
0.76 0.6 1 0.35 0.24 0.17 -0.48 -0.28
-0.27 -0.43 0.35 1 0.98 0.98 0.6 0.69
-0.35 -0.51 0.24 0.98 1 0.99 0.68 0.75
-0.4 -0.54 0.17 0.98 0.99 1 0.7 0.76
-0.87 -0.97 -0.48 0.6 0.68 1
-0.76 -0.79 -0.28 0.69 0.75 0.87 1
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75

lightIntensityR
lightIntensityS
lightIntensityT
lightIntensityU
lightIntensityV
lightIntensityW
NDVI_x
NDVI_y

https://iot-polje.fer.hr/iot-polje

O PROJEKTU NOVOSTI ISTRAŽIVAČKI TIM PUBLIKACIJE RADIONICE KONTA

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Partneri:

FERIT

POLJOPRIVREDNI INSTITUT OSIJEK

Ekosustav umreženih uređaja i usluga za Internet stvari s primjenom u poljoprivredi

IoT-polje

Internet stvari (*Internet of Things*, IoT) ima značajan potencijal za **primjenu u poljoprivredi** jer omogućuje kontinuirano prikupljanje i obradu mikroklimatskih i agronomskih podataka radi optimizacije i

najčešći uzrok nerentabilnih prinosa najvažnijih k
entni procesi klimatskih promjena značajno utjec
održivost proizvodnje poljoprivrednih kultura od strateške važnosti za RH.

Projekt *Ekosustav umreženih uređaja i usluga za Internet stvari s primjenom u poljoprivredi* (skr. ***IoT-polje***) će pot primjenu IoT rješenja u poljoprivredi u RH kroz interdisciplinarna istraživanja **Fakulteta elektrotehnike i računa** (FER), **Fakulteta elektrotehnike, računarstva i informacijskih tehnologija** (FERIT) i **Poljoprivrednog instituta O** (PIO) radi **smanjenja utjecaja klimatskih promjena na poljoprivredne prinose** u RH korištenjem naprednih tehnologija i dostupnih izvora podataka o stanju usjeva i okoliša. Projektne aktivnosti su usmjerene na istraživ razvoj interoperabilnih i sigurnih tehničkih rješenja ekosustava za prikupljanje i naprednu obradu stvarnovreme mikroklimatskih i agronomskih podataka, radi unaprjeđenja biljne proizvodnje u RH. Ekosustav će integrirati post dostupnu infrastrukturu i izvore podataka te uvesti inovativna tehnička rješenja za cjelovitu slika o stanju usje omogućuje

1. primjenu statističkih metoda nad sasvim novim skupovima podataka i
2. uvođenje novih praktičnih aplikacija za različite dionike u poljoprivredi.

Posebna će se pozornost posvetiti istraživanju **utjecaja suše** na biljnu proizvodnju radi primjene pravovre agrotehničkih mjera i procjene fiziološkog stanja usjeva na temelju fluorescencije klorofila. Predviđa se dizajn i **inovativnog umreženog uređaja za mjerenje fluorescencije klorofila u stvarnom vremenu** te odgovarajuće be senzorske mreže. Potom se planira primjena blok-lanca za praćenje

1. stanja usjeva,
2. provedenih agrotehničkih i fitomedicinskih mjera i
3. poštivanja zakonskih direktiva vezano za primjenu pesticida.

Cilj projekta je povećati tržišno orijentirane IRI aktivnosti u područjima Interneta stvari i biljnih znanosti za uspo ekosustava umreženih uređaja i inovativnih usluga s primjenom u poljoprivredi. Važnost projekta se ogleda u znač