

**GOCE DELCEV UNIVERSITY, STIP, NORTH MACEDONIA
FACULTY OF ELECTRICAL ENGINEERING**

ETIMA 2025

THIRD INTERNATIONAL CONFERENCE

24-25 SEPTEMBER, 2025



**TECHNICAL SCIENCES APPLIED IN ECONOMY,
EDUCATION AND INDUSTRY**



УНИВЕРЗИТЕТ
ГОЦЕ ДЕЛЧЕВ
ЕЛЕКТРОТЕХНИЧКИ
ФАКУЛТЕТ



УНИВЕРЗИТЕТ „ГОЦЕ ДЕЛЧЕВ“, ШТИП
ЕЛЕКТРОТЕХНИЧКИ ФАКУЛТЕТ

GOCE DELCEV UNIVERSITY, STIP
FACULTY OF ELECTRICAL ENGINEERING

ТРЕТА МЕЃУНАРОДНА КОНФЕРЕНЦИЈА
THIRD INTERNATIONAL CONFERENCE

ЕТИМА / ETIMA 2025

ЗБОРНИК НА ТРУДОВИ
CONFERENCE PROCEEDINGS

24-25 септември 2025 | 24-25 September 2025

ISBN: 978-608-277-128-1

DOI: <https://www.doi.org/10.46763/ETIMA2531>

Главен и одговорен уредник / Editor in Chief

проф.д-р Сашо Гелев
Prof.d-r Saso Gelev

Јазично уредување / Language Editor

Весна Ристова (македонски) / Vesna Ristova (Macedonian)

Техничко уредување / Technical Editing

Дарко Богатинов / Darko Bogatinov

Издавач / Publisher

Универзитет „Гоце Делчев“, Штип / Goce Delcev University, Stip
Електротехнички факултет / Faculty of Electrical Engineering

Адреса на организационен комитет / Address of the organizational committee

Универзитет „Гоце Делчев“, Штип / Goce Delcev University, Stip
Електротехнички факултет / Faculty of Electrical Engineering

Адреса: ул. „Крсте Мисирков“ бр. 10А / Address: Krste Misirkov, 10A

Пош. фах 201, Штип - 2000, С. Македонија / PO BOX 201, Stip 2000, North Macedonia

E-mail: conf.etf@ugd.edu.mk

CIP - Каталогизација во публикација

Национална и универзитетска библиотека "Св. Климент Охридски", Скопје

62-049.8(062)

004-049.8(062)

МЕЃУНАРОДНА конференција ЕТИМА (3 ; 2025 ; Штип)

Зборник на трудови [Електронски извор] / Трета меѓународна конференција ЕТИМА 2025, 24-25 септември 2025 ; [главен и одговорен уредник Сашо Гелев] = Conference proceedings / Third international conference, 24-25 September 2025 ; [editor in chief Saso Gelev]. - Текст во PDF формат, содржи 357 стр., илустр. - Штип : Универзитет "Гоце Делчев", Електротехнички факултет ; Штип : "Goce Delchev" University, Faculty of Electrical engineering, 2025

Начин на пристапување (URL): <https://js.ugd.edu.mk/index.php/etima/en>. - Наслов преземен од екранот. - Опис на изворот на ден 30.10.2025. - Трудови на мак. и англ. јазик. - Библиографија кон трудовете

ISBN 978-608-277-128-1

а) Електротехника -- Примена -- Собири б) Машинство -- Примена -- Собири
в) Автоматика -- Примена -- Собири г) Информатика -- Примена -- Собири

COBISS.MK-ID 67297029



Трета меѓународна конференција ЕТИМА
24-25 Септември 2025
Third International Conference ETIMA
24-25 September 2025

**ОРГАНИЗАЦИОНЕН ОДБОР
ORGANIZING COMMITTEE**

Драган Миновски / Dragan Minovski

Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Сашо Гелев / Saso Gelev

Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Тодор Чекеровски / Todor Cekerovski

Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Маја Кукушева Панева / Maja Kukuseva Paneva

Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Билјана Читкушева Димитровска / Biljana Citkuseva Dimitrovska

Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Дарко Богатинов / Darko Bogatinov

Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia



Трета меѓународна конференција ЕТИМА
24-25 Септември 2025
Third International Conference ETIMA
24-25 September 2025

**ПРОГРАМСКИ И НАУЧЕН ОДБОР
SCIENTIFIC COMMITTEE**

Антонио Курадо / António Curado

Политехнички институт во Виана до Кастело, Португалија
Instituto Politécnico de Viana do Castelo, Portugal

Стелијан – Емилијан Олтеан / Stelian –Emilian Oltean

Факултет за инженерство и информатичка технологија,
Медицински универзитет Георге Емил Паладе, фармација, наука и технологија
во Таргу Муреш, Романија
Faculty of Engineering and Information Technology, George Emil Palade
University of Medicine, Pharmacy, Science, and Technology of Targu Mures, Romania

Митко Богданоски / Mitko Bogdanoski

Воена академија, Универзитет „Гоце Делчев“, Северна Македонија
Military Academy, Goce Delcev University, North Macedonia

Верица Тасеска Ѓоргиевска / Verica Taseska Gjorgievska

Македонска академија на науките и уметностите, Северна Македонија
Macedonian Academy of Sciences and Arts, North Macedonia

Југослав Ачкоски / Jugoslav Ackoski

Воена академија, Универзитет „Гоце Делчев“, Северна Македонија
Military Academy, Goce Delcev University, North Macedonia

Димитар Богатинов / Dimitar Bogatinov

Воена академија, Универзитет „Гоце Делчев“, Северна Македонија
Military Academy, Goce Delcev University, North Macedonia

Со Ногучи / So Noguchi

Висока школа за информатички науки и технологии
Универзитет Хокаидо, Јапонија
Graduate School of Information Science and Technology
Hokkaido University, Japan

Диониз Гашпаровски / Dionýz Gašparovský

Факултет за електротехника и информатички технологии,
Словачки Технички Универзитет во Братислава, Словачка
Faculty of Electrical Engineering and Information Technology
Slovak Technical University in Bratislava, Slovakia

Георги Иванов Георгиев / Georgi Ivanov Georgiev
Технички Универзитет во Габрово, Бугарија
Technical University in Gabrovo, Bulgaria

Антон Белан / Anton Belán
Факултет за електротехника и информациони технологии
Словачки Технички Универзитет во Братислава, Словачка
Faculty of Electrical Engineering and Information Technology
Slovak Technical University in Bratislava, Slovakia

Ивелина Стефанова Балабанова / Ivelina Stefanova Balabanova
Технички Универзитет во Габрово, Бугарија
Technical University in Gabrovo, Bulgaria

Бојан Димитров Карапeneв / Boyan Dimitrov Karapenev
Технички Универзитет во Габрово, Бугарија
Technical University in Gabrovo, Bulgaria

Сашо Гелев / Saso Gelev
Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Влатко Чингоски / Vlatko Cingoski
Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Божо Крстајиќ / Bozo Krstajic
Електротехнички факултет
Универзитет во Црна Гора, Црна Гора
Faculty of Electrical Engineering,
University in Montenegro, Montenegro

Милован Радуловиќ / Milovan Radulovic
Електротехнички факултет
Универзитет во Црна Гора, Црна Гора
Faculty of Electrical Engineering,
University in Montenegro, Montenegro

Гоце Стефанов / Goce Stefanov
Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Мирјана Периќ / Mirjana Peric
Електронски факултет
Универзитет во Ниш, Србија
Faculty of Electronic Engineering,
University of Nis, Serbia

Ана Вучковиќ / Ana Vuckovic

Електронски факултет,
Универзитет во Ниш, Србија
Faculty of Electronic Engineering,
University of Nis, Serbia

Тодор Чекеровски / Todor Cekerovski

Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Далибор Серафимовски / Dalibor Serafimovski

Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Мирослава Фаркаш Смиткова / Miroslava Farkas Smitková

Факултет за електротехника и информации технологии
Словачки Технички Универзитет во Братислава, Словачка
Faculty of Electrical Engineering and Information Technology
Slovak Technical University in Bratislava, Slovakia

Петер Јанига / Peter Janiga

Факултет за електротехника и информации технологии
Словачки Технички Универзитет во Братислава, Словачка
Faculty of Electrical Engineering and Information Technology
Slovak Technical University in Bratislava, Slovakia

Јана Радичова / Jana Raditschová

Факултет за електротехника и информации технологии
Словачки Технички Универзитет во Братислава, Словачка
Faculty of Electrical Engineering and Information Technology
Slovak Technical University in Bratislava, Slovakia

Драган Миновски / Dragan Minovski

Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Василија Шарац / Vasilija Sarac

Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Александар Тузаров / Aleksandar Tudzarov

Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Владимир Талевски / Vladimir Talevski

Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Владо Гичев / Vlado Gicev

Факултет за информатика,
Универзитет „Гоце Делчев“, Штип, Северна Македонија;
Faculty of Computer Science,
Goce Delcev University, Stip, North Macedonia;

Марија Чекеровска / Marija Cekerovska

Машински факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија;
Faculty of Mechanical Engineering,
Goce Delcev University, Stip, North Macedonia;

Мишко Цидров / Misko Dzidrov

Машински факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија;
Faculty of Mechanical Engineering,
Goce Delcev University, Stip, North Macedonia;

Александар Крстев / Aleksandar Krstev

Факултет за информатика,
Универзитет „Гоце Делчев“, Штип, Северна Македонија;
Faculty of Computer Science,
Goce Delcev University, Stip, North Macedonia;

Ванчо Аџиски / Vancho Adziski

Факултет за природни и технички науки,
Универзитет „Гоце Делчев“, Штип, Северна Македонија;
Faculty of Natural and Technical Sciences,
Goce Delcev University, Stip, North Macedonia;

Томе Димовски / Tome Dimovski

Факултет за информатички и комуникациски технологии,
Универзитет „Св. Климент Охридски“, Северна Македонија;
Faculty of Information and Communication Technologies,
University St Climent Ohridski, North Macedonia;

Зоран Котевски / Zoran Kotevski

Факултет за информатички и комуникациски технологии,
Универзитет „Св. Климент Охридски“, Северна Македонија;
Faculty of Information and Communication Technologies,
University St Climent Ohridski, North Macedonia;

Никола Рендевски / Nikola Rendeovski

Факултет за информатички и комуникациски технологии,
Универзитет „Св. Климент Охридски“, Северна Македонија;
Faculty of Information and Communication Technologies,
University St Climent Ohridski, North Macedonia;

Илија Христовски / Ilija Hristovski

Економски факултет,
Универзитет „Св. Климент Охридски“, Северна Македонија;
Faculty of Economy,
University St Climent Ohridski, North Macedonia;

Христина Спасовска / Hristina Spasovska

Факултет за електротехника и информациски технологии,
Универзитет „Св. Кирил и Методиј“, Скопје, Северна Македонија;
Faculty of Electrical Engineering and Information Technologies,
Ss. Cyril and Methodius University, North Macedonia;

Роман Голубовски / Roman Golubovski

Природно-математички факултет,
Универзитет „Св. Кирил и Методиј“, Скопје, Северна Македонија;
Faculty of Mathematics and Natural Sciences,
Ss. Cyril and Methodius University, North Macedonia;

Маре Србиновска / Mare Srbinovska

Факултет за електротехника и информациски технологии,
Универзитет „Св. Кирил и Методиј“, Скопје, Северна Македонија;
Faculty of Electrical Engineering and Information Technologies,
Ss. Cyril and Methodius University, North Macedonia;

Билјана Златановска / Biljana Zlatanovska

Факултет за информатика,
Универзитет „Гоце Делчев“, Штип, Северна Македонија;
Faculty of Computer Science,
Goce Delcev University, Stip, North Macedonia;

Александра Стојанова Илиевска / Aleksandra Stojanova Ilievska

Факултет за информатика,
Универзитет „Гоце Делчев“, Штип, Северна Македонија;
Faculty of Computer Science,
Goce Delcev University, Stip, North Macedonia;

Мирјана Коцалева Витанова / Mirjana Kocaleva Vitanova

Факултет за информатика,
Универзитет „Гоце Делчев“, Штип, Северна Македонија;
Faculty of Computer Science,
Goce Delcev University, Stip, North Macedonia;

Ивана Сандева / Ivana Sandeva

Факултет за електротехника и информациски технологии,
Универзитет „Св. Кирил и Методиј“, Скопје, Северна Македонија;
Faculty of Electrical Engineering and Information Technologies,
Ss. Cyril and Methodius University, North Macedonia;

Билјана Читкушева Димитровска / Biljana Citkuseva Dimitrovska

Електротехнички факултет,
Универзитет „Гоце Делчев“, Штип, Северна Македонија;
Faculty of Electrical Engineering,
Goce Delcev University, Stip, North Macedonia

Наташа Стојковиќ / Natasa Stojkovik

Факултет за информатика,

Универзитет „Гоце Делчев“, Штип, Северна Македонија;

Faculty of Computer Science,

Goce Delcev University, Stip, North Macedonia;



Трета меѓународна конференција ЕТИМА Third International Conference ETIMA

PREFACE

The Third International Conference “Electrical Engineering, Technology, Informatics, Mechanical Engineering and Automation – Technical Sciences in the Service of the Economy, Education and Industry” (ETIMA’25), organized by the Faculty of Electrical Engineering at the “Goce Delchev” University – Shtip, represents a significant scientific event that enables interdisciplinary exchange of knowledge and experience among researchers, professors, and experts in the field of technical sciences. The conference was held in an online format and brought together 78 authors from five different countries.

The ETIMA conference aims to establish a forum for scientific communication, encouraging multidisciplinary collaboration and promoting technological innovations with direct impact on modern life. Through the presentation of scientific papers, participants shared the results of their research and development activities, contributing to the advancement of knowledge and practice in relevant fields. The first ETIMA conference was organized four years ago, featuring 40 scientific papers. The second conference took place in 2023 and included over 30 papers. ETIMA’25 continued this scientific tradition, presenting more than 40 papers that reflect the latest achievements in electrical engineering, technology, informatics, mechanical engineering, and automation.

At ETIMA’25, papers were presented that addressed current topics in technical sciences, with particular emphasis on their application in industry, education, and the economy. The conference facilitated fruitful discussions among participants, encouraging new ideas and initiatives for future research and projects.

ETIMA’25 reaffirmed its role as an important platform for scientific exchange and international cooperation. The organizing committee extends sincere gratitude to all participants for their contribution to the successful realization of the conference and its scientific value.

We extend our sincerest gratitude to all colleagues who, through the presentation of their papers, ideas, and active engagement in discussions, contributed to the success and scientific significance of ETIMA’25.

The Organizing Committee of the Conference

ПРЕДГОВОР

Третата меѓународна конференција „Електротехника, Технологија, Информатика, Машинство и Автоматика – технички науки во служба на економијата, образованието и индустријата“ (ЕТИМА’25), организирана од Електротехничкиот факултет при Универзитетот „Гоце Делчев“ – Штип, претставува значаен научен настан кој овозможува интердисциплинарна размена на знаења и искуства меѓу истражувачи, професори и експерти од техничките науки. Конференцијата се одржа во онлајн формат и обедини 78 автори од пет различни земји.

Конференцијата ЕТИМА има за цел да создаде форум за научна комуникација, поттикнувајќи мултидисциплинарна соработка и промовирајќи технолошки иновации со директно влијание врз современото живеење. Преку презентација на научни трудови, учесниците ги споделуваат резултатите од своите истражувања и развојни активности, придонесувајќи кон унапредување на знаењето и практиката во релевантните области.

Првата конференција ЕТИМА беше организирана пред четири години, при што беа презентирани 40 научни трудови. Втората конференција се одржа во 2023 година и вклучи над 30 трудови. ЕТИМА’25 продолжи со истата научна традиција, презентирајќи повеќе од 40 трудови кои ги отсликуваат најновите достигнувања во областа на електротехниката, технологијата, информатиката, машинството и автоматиката.

На ЕТИМА’25 беа презентирани трудови кои обработуваат актуелни теми од техничките науки, со посебен акцент на нивната примена во индустријата, образованието и економијата. Конференцијата овозможи плодна дискусија меѓу учесниците, поттикнувајќи нови идеи и иницијативи за идни истражувања и проекти.

ЕТИМА’25 ја потврди својата улога како значајна платформа за научна размена и интернационална соработка. Организациониот одбор упатува искрена благодарност до сите учесници за нивниот придонес кон успешната реализација на конференцијата и нејзината научна вредност. Конференцијата се одржа онлајн и обедини седумдесет и осум автори од пет различни земји.

Изразуваме голема благодарност до сите колеги кои со презентирање на своите трудови, идеи и активна вклученост во дискусиите придонесоа за успехот на ЕТИМА’25 и нејзината научна вредност.

Организационен одбор на конференцијата

СОДРЖИНА / TABLE OF CONTENTS:

СОВРЕМЕНО РАНОГРАДИНАРСКО ПРОИЗВОДСТВО СО ПРИМЕНА НА ОБНОВЛИВИ ЕНЕРГЕТСКИ ИЗВОРИ И ТЕХНОЛОГИИ.....	15
ШИРОКОПОЈАСЕН ПРЕНОС НА ПОДАТОЦИ ПРЕКУ ЕЛЕКТРОЕНЕРГЕТСКАТА МРЕЖА	25
TRANSIENT PHENOMENA IN BLACK START	32
OPTIMIZATION OF SURPLUS ELECTRICITY MANAGEMENT FROM MUNICIPAL PHOTOVOLTAIC SYSTEMS: VIRTUAL STORAGE VS BATTERY SYSTEMS.....	43
IMPACT OF LIGHT POLLUTION ON ENERGY EFFICIENCY	53
ПЕРСПЕКТИВИ, ПРЕДИЗВИЦИ И ИНОВАЦИИ ВО ПЕРОВСКИТНИТЕ СОЛАРНИ КЕЛИИ	61
ПРИМЕНА НА НАНОМАТЕРИЈАЛИ КАЈ ФОТОВОЛТАИЧНИ КЕЛИИ ЗА ЗГОЛЕМУВАЊЕ НА НИВНАТА ЕФИКАСНОСТ ПРЕКУ НАМАЛУВАЊЕ НА РАБОТНАТА ТЕМПЕРАТУРА	68
LONG-TERM POWER PURCHASE AGREEMENT FOR PHOTOVOLTAIC ENERGY AS A SOLUTION FOR ENHANCING THE PROFITABILITY OF THE TASHMARUNISHTA PUMPED-STORAGE HYDRO POWER PLANT	75
СПОРЕДБЕНА АНАЛИЗА НА ПОТРОШУВАЧКА, ЕНЕРГЕТСКА ЕФИКАСНОСТ И ТРОШОЦИ КАЈ ВОЗИЛА СО РАЗЛИЧЕН ТИП НА ПОГОН	87
АВТОМАТСКИ СИСТЕМ ЗА НАВОДНУВАЊЕ УПРАВУВАН ОД ARDUINO МИКРОКОНТРОЛЕР	95
ПРИМЕНА НА WAMS И WACS СИСТЕМИ ВО SMART GRID.....	103
IoT-BASED ENVIRONMENTAL CONTROL IN 3D PRINTER ENCLOSURES FOR OPTIMAL PRINTING CONDITIONS.....	112
BENEFITS OF STUDYING 8086 MICROPROCESSOR FOR UNDERSTANDING CONTEMPORARY MICROPROCESSOR.....	123
ПРАКТИЧНА СИМУЛАЦИЈА НА SCADA СИСТЕМ ЗА СЛЕДЕЊЕ И РЕГУЛАЦИЈА НА НИВО НА ТЕЧНОСТ ВО РЕЗЕРВОАР.....	130
ADVANCEMENTS IN INDUSTRIAL DIGITAL SENSORS (VERSION 3.0 TO 4.0) AND RADAR SYSTEMS FOR OBJECT DETECTION: A STATE-OF-THE-ART REVIEW.	140
CHALLENGES AND SOLUTIONS FOR ENHANCING DRONE-TO-TOC COMMUNICATION PERFORMANCE IN MILITARY AND CRISIS OPERATIONS..	148
BRIDGING TELECOM AND AVIATION: ENABLING SCALABLE BVLOS DRONE OPERATIONS THROUGH AIRSPACE DIGITIZATION.....	157
MEASURES AND RECOMMENDATIONS FOR EFFICIENCY IMPROVEMENT OF ELECTRICAL MOTORS	167
USE OF MACHINE LEARNING FOR CURRENT DENSITY DISTRIBUTION ESTIMATION OF REBCO COATED CONDUCTORS	180
APPLICATION OF ARTIFICIAL INTELLIGENCE IN DENTAL MEDICINE	186
ИНТЕГРАЦИЈА НА ДИГИТАЛНИОТ СПЕКТРОФОТОМЕТАР ВО ДЕНТАЛНАТА МЕДИЦИНА – НОВИ МОЖНОСТИ ЗА ТОЧНОСТ И КВАЛИТЕТ	194

CORRELATION OF DENTAL MEDICINE STUDENTS' PERFORMANCE IN PRECLINICAL AND CLINICAL COURSES	205
INTRAORAL ELECTROSTIMULATOR FOR RADIATION INDUCED XEROSTOMIA IN PATIENTS WITH HEAD AND NECK CANCER.....	214
ELECTROMAGNETIC INTERFERENCE OF ENDODONTIC EQUIPMENT WITH GASTRIC PACEMAKER	221
DENTAL IMPLANTS ANALYSIS WITH SEM MICROSCOPE	226
ПРЕДНОСТИ И НЕДОСТАТОЦИ ПРИ УПОТРЕБА НА ЛАСЕР ВО РЕСТАВРАТИВНАТА СТОМАТОЛОГИЈА И ЕНДОДОНЦИЈА.....	231
LASERS AND THEIR APPLICATION IN PEDIATRIC DENTISTRY	238
INCREASE OF ENVIRONMENTALLY RESPONSIBLE BEHAVIOUR THROUGH EDUCATION AND TECHNOLOGICAL INNOVATION.....	242
A DATA-DRIVEN APPROACH TO REAL ESTATE PRICE ESTIMATION: THE CASE STUDY SLOVAKIA.....	249
ANALYSIS OF THE BACKWARD IMPACTS OF A PHOTOVOLTAIC POWER PLANT ON THE DISTRIBUTION SYSTEM	261
VARIANT SOLUTIONS FOR A PARKING LOT COVERED WITH PHOTOVOLTAIC PANELS.....	268
COMPARISON OF ENERGY STATUS IN PORTUGAL AND IN SLOVAKIA	279
DESIGN, ANALYSIS AND IMPLEMENTATION OF PHOTOVOLTAIC SYSTEMS ...	286
BATTERY STORAGE IN TRACTION POWER SUPPLY	297
THE ROLE OF CYBERSECURITY AWARENESS TRAINING TO PREVENT PHISHING.....	304
A REVIEW OF RESOURCE OPTIMIZATION TECHNIQUES IN INTRUSION DETECTION SYSTEMS	311
APPLICATION OF A ROBOTIC ARM IN A SIMPLE PICK-AND-DROP OPERATION	321
SIMULATION-BASED PERFORMANCE ANALYSIS OF A SECURE UAV-TO-TOC COMMUNICATION FRAMEWORK IN MILITARY AND EMERGENCY OPERATIONS	328
DIGITALIZATION OF BPM USING THE CAMUNDA SOFTWARE TOOL ON THE EXAMPLE OF THE CENTRAL BANK OF MONTENEGRO	339
DESIGNING A SECURE COMMUNICATION FRAMEWORK FOR UAV-TO-TOC OPERATIONS IN MILITARY AND EMERGENCY ENVIRONMENTS.....	349



APPLICATION OF A ROBOTIC ARM IN A SIMPLE PICK-AND-DROP OPERATION

Darko Bogatinov¹, Dejan Krstev², Saso Gelev¹

1 Faculty of Electrical Engineering, Goce Delcev University, Krste Misirkov 10A, 2000 Stip, North Macedonia,
email: darko.bogatinov@ugd.edu.mk

email: saso.gelev@ugd.edu.mk

2 Faculty of Mechanical Engineering, Goce Delcev University, Krste Misirkov 10A, 2000 Stip, North Macedonia
email: dejan.krstev@ugd.edu.mk

Abstract

The robotic arm is one of the most significant innovations in the field of robotics and automation, offering numerous opportunities for improving efficiency and precision in industrial processes. This paper focuses on the application of robotic arms in the industry for the automation of various tasks, such as transferring materials from one place to another, assembling products, welding, painting, packaging and quality control, etc. Through an analysis of modern technologies and trends, the paper explores the benefits of introducing robotic arms into production lines, including increased productivity, reduced costs and improved worker safety. It also discusses the challenges associated with implementation, such as the high initial investment, the need for specialized personnel and ethical issues. In the practical part of the paper, we use the DOBOT MG400 robotic arm to transfer work material from one point to another in a production process.

Key words

robotic arm, industrial automation, productivity, precision, efficiency.

1.Introduction

Industrial robotics is a key component in the process of automating production. Robots are used to perform various tasks that require precision, repeatability, and speed, reducing dependence on human labor. Simple robotic systems such as DOBOT have proven ideal for use in educational institutions, where students can gain hands-on experience with programming and robot control. The aim of this paper is to demonstrate the application of the DOBOT robotic arm through the implementation of a Pick and Place operation using DobotStudio software. The DOBOT MG400 offers repeat positioning precision of $\pm 0.05\text{mm}$ and a maximum load of 500g. It is a product that combines the advantages of industrial and educational robots.

The field of robotics is interdisciplinary and holds great promise for education [9]. To appreciate its concept, it demands various fields of knowledge. In recent years, as it was reported in [1], we saw a growing presence of Robots in the educational market, not only as tools to motivate students to explore STEM (Science, Technology, Engineering and Mathematics) areas, but eventually as actual curriculum elements to teach content. In fact, a number of attempts have been made throughout the world to establish robotics in elementary science and technology education, i.e., in elementary schools and high schools [2]. It can be

taught in class, as projects or even by competition as it encourages the students to develop solutions to tasks [3].



Figure 1. DOBOT MG400 robotic arm

2. Application of Industrial Robots in Modern Manufacturing

In modern industry, the most commonly used robots are robotic arms. The term "robotic arms" refers to manipulators that mimic human arms. They are made up of a framework made up of links that are both structurally sound and connected by either translating or rotating joints. Therefore, a robotic arm is a kind of mechanically connected or joined arm that performs tasks akin to those of a human arm [5] and is controlled by programmable orders. It could be a component of a larger, more intricate robot or the sum of the mechanism links.

The parts of a typical robotic arm are including the following:

- Joints and links
- End-effector;
- Actuators;
- Controller

A link is a rigid body that establishes the connection between two of a manipulator's corresponding joint axes. The rigid links that make up manipulators are joined by joints that permit the matching links to move relative to one another.

Actuators transform stored energy into movement energy [5], much like the muscles in a human arm do. The manipulator joints of a robot are moved by means of actuators. These days, modern robots typically use three different kinds of actuators: electrical, hydraulic, and pneumatic.

Actuators powered by electric motors move more smoothly, are incredibly dependable, and can be precisely controlled. However, compared to hydraulic actuators of similar mass, mechanical actuators are unable to produce as much power. However, electrical actuators are frequently chosen for low power actuator applications. Stepper motors, servo motors, and direct current (DC) motors are the several kinds of electric motors used as actuators in robotic applications. The primary component of a robot that interprets data and executes commands is the controller [6]. It serves as the "brain" of the robot and directs its actions. Typically, some sort of computer is utilized to store data on the robot and its operation as well as run programs that control the robot. It has programs, data algorithms, logic analysis, and other processing operations that let the robot do what it's supposed to do. An end-effector is a tool used to interact with the outside environment that is attached to the end of a robotic arm [5]. The robot's application determines

the precise nature of its performance. Gripping, pushing and tugging, twisting, utilizing tools, making insertions, welding, and other kinds of assembly tasks are typical end-effector functions. [4]

Industrial robots are used in a wide range of applications: welding, cutting, packaging, palletizing, assembly, quality control, etc. In recent years, there has been a growing trend in the use of small and flexible robots for simple tasks in smaller production facilities. Their use leads to increased efficiency, error reduction, and resource optimization. One of the most common types of applications is Pick and Place, enabling precise transfer of objects from one position to another [10].

Industrial automation with robotic arms offers not only productivity improvements but also the ability to perform repetitive or hazardous tasks with consistent quality. The integration of robots can also improve traceability in manufacturing by logging each step digitally. This allows for better data collection and process optimization.

3.DOBOT Robotic Arm – Features and Tools

The The DOBOT robotic arm distinguishes itself as a compact, precise, and accessible solution [8] for both educational and light industrial use. Designed with flexibility and ease of integration in mind, it bridges the gap between academic training and practical automation tasks.

DOBOT offers several key functionalities:

- End-effector versatility: The robot supports a vacuum suction cup or mechanical gripper, enabling handling of a variety of object types.
- Visual programming interface: Through the Blockly environment in DobotStudio [8], users can develop complex sequences without prior coding experience.
- Command flexibility: The software supports motion control, input/output configuration, time delays, logical operations, custom functions, and variable manipulation.

Specifically, the DOBOT MG400 model provides the following technical specifications:

- Payload capacity: up to 500 grams, suitable for lightweight components or materials.
- Repeatability: ± 0.05 mm, ensuring high precision in repeated cycles.
- Reach: 440 mm maximum, enabling interaction with components placed across small workspaces.
- Compact footprint: Designed for benchtop use in classrooms or small automation cells.
- Windows OS compatibility: Seamless operation on standard personal computers.

The DobotStudio platform enhances usability through its drag-and-drop block-based programming approach. Key features of the software include:

- Real-time control and monitoring of the robotic arm.
- Simulation environment for offline development and testing.
- Built-in calibration tools to optimize performance.
- Support for transitioning to advanced programming via Python, LUA, or C APIs.

Overall, the DOBOT system enables scalable learning: from introductory robotics to integration with vision systems, conveyors, and sensors. It represents a practical entry point into the field of robotics, blending intuitive software with robust mechanical design.

4. Programming the Pick and Place Operation for DOBOT MG400 in DobotStudio software

Robotic arms are excellent for performing Pick and Place operations, their use in industry is in processes such as placing small electronic components on boards, as well as large boxes on pallets. To perform the Pick and Place operation, it is necessary to define at least 5 positions:

- Starting position
- Position above the object to be lifted
- Position of the object itself to be lifted
- Position above the place where the object is to be left
- Position at the place of leaving

In the following, we will look at how to program the robot to perform the Pick and Place operation using blocks. In the program itself, we will look at how to program the robot's movement and how to turn the vacuum on and off on the robotic arm. First, we start the DobotStudio software, Figure 2 shows the initial screen that is displayed after starting the program.

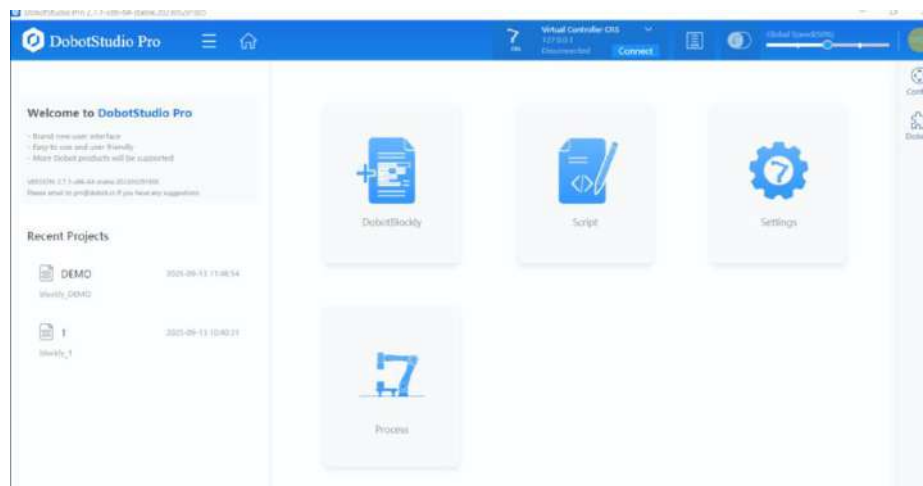


Figure 2. Initial screen of DobotStudio software

On the home screen itself, we can choose whether we want to start with a new file, or we can select an existing file that has been previously saved and upgrade it. To select an existing file, we click and select it from the Recent Projects section; to create a new file we click on the DobotBlockly icon. After clicking on the DobotBlockly icon, a new window opens in which we can start adding blocks that represent commands for the robotic arm.

As we have already mentioned, it is important to first determine the positions themselves, that is, the coordinates along the x, y and z axes, which are used to obtain the position of the robotic arm. The easiest way to determine the coordinates is to put the robotic arm in manual mode and freely move it to the place we want it to reach. In the DobotStudio software itself, we see the movement of the robotic arm in real time, so after manually moving the robotic arm, we can also see the coordinates of the desired position.

Figure 3 shows the part of the software where we can read the values of the coordinates along the x, y and z axes.

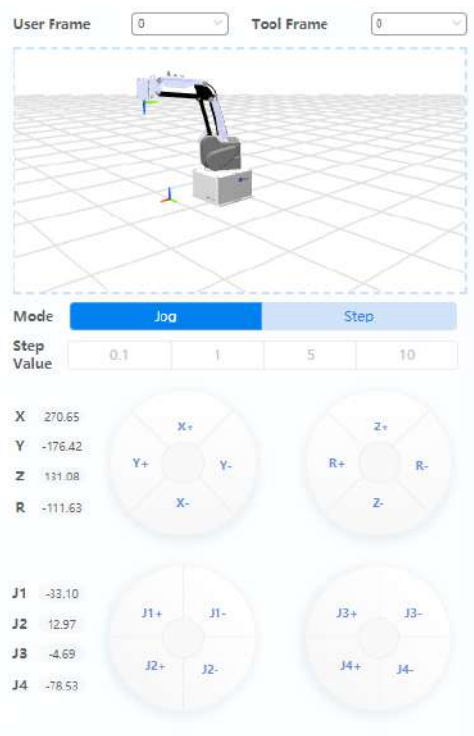


Figure 3. Values of the coordinates along the x, y and z axes.

After we have determined all the coordinates or positions that the robotic arm needs to reach, we can start adding the blocks to the program. The block that is used to move the robotic arm is located in the Move commands category, from where we select it and add it to the section where we create the program. Each program begins with the Start block and the remaining blocks are specified in the following. After adding the Move to block, we need to add the coordinates along the x, y and z axes to which we want the robotic arm to be moved. Figure 4 shows the Move block and the part where we enter the coordinates of the position itself.



Figure 4. Move to block setup

Once the robotic arm reaches the position above the object to be lifted, it is necessary to add the block that will activate the vacuum on the end element itself so that the desired object can be lifted. This block is located in the I/O category. Once the robotic arm reaches the position where the object itself should be left, the vacuum needs to be turned off to lower the object to the desired position. Figure 5 shows the block program for picking up two objects from a certain position and placing them in another position, one on top of the other.

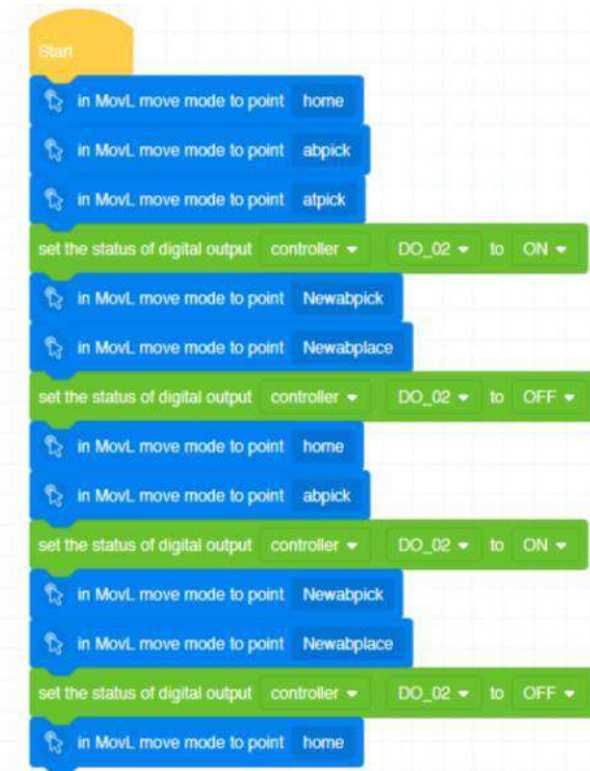


Figure 5. Block program for picking and place operation

5. Implementation and Results

The Pick and Place operation was successfully implemented include the following:

- The arm moves above the object
- The vacuum is activated and the object is picked up
- The arm moves to the new location
- The vacuum is deactivated and the object is placed
- The process is repeated for a second object

In the actual application, two objects were picked and stacked one over the other at the final position. Coordinate precision and timing intervals were crucial for successful implementation. The program was tested multiple times, showing stable behavior with no errors in positioning or actuator control.



Figure 6. Pick and Place operation with DOBOT MG400

6. Discussion

The DOBOT system demonstrates high stability and ease of programming, making it suitable for beginner applications. Key advantages include:

- Fast setup
- Intuitive programming
- Expandability with sensors
- Built-in safety limits and emergency stop features

A limitation is the restricted range of motion and payload capacity, which confines it to lightweight applications. The MG400 model, for instance, is ideal for training environments and light materials but not suitable for heavy-duty tasks. However, for educational purposes and demonstrations of automation, it is an excellent choice.

The system is scalable through integration with conveyor belts, color sensors, and vision modules, which can simulate more realistic industrial environments. Students can also transition from Blockly to scripting languages (e.g., Python, LUA) supported by DOBOT SDK for more advanced development.

7. Conclusion

The DOBOT robotic arm was successfully applied for the implementation of a Pick and Place task using visual programming in DobotStudio. By defining coordinates and controlling the vacuum actuator, a stable operation was achieved that can serve as a foundation for further development of automated systems. This type of robot holds significant potential in education and entry-level automation. The platform encourages experiential learning and offers a practical gateway [9] toward understanding industrial robotics. Future enhancements may include integration with external PLCs and industrial networks to simulate real-world industrial scenarios.

References

- [1] Miller, D. P., Nourbakhsh, I.: Robotics for education. In Springer handbook of robotics (pp. 2115-2134). Springer, Cham. (2016).
- [2] Alimisis, D., Kynigos, C.: Constructionism and robotics in education. Teacher education on robotic-enhanced constructivist pedagogical methods, 11-26. (2009).
- [3] Braun, J., Fernandes, L. A., Moya, T., Oliveira, V., Brito, T., Lima, J., Costa, P.: Robot@ Factory Lite: An Educational Approach for the Competition with Simulated and Real Environment. In Iberian Robotics conference (pp. 478-489). Springer, Cham. (2019, November).
- [4] Talakayala, Dr Sunil & Sarath, K & Famil, Sd & Bhagyesh, A & Althaf, Sk. (2020). Design and fabrication of pick and place robotic arm.
- [5] Siciliano, B., & Khatib, O. (2016). Springer Handbook of Robotics. Springer.
- [6] Gertler, J. (2017). Intelligent Control: Emerging Trends. Academic Press.
- [7] Mataric, M. J. (2004). The Robotics Primer. MIT Press.
- [8] Dobot Team. (2023). DOBOT MG400 User Manual. Shenzhen Yuejiang Technology.
- [9] Alimisis, D. (2013). Robotics in education: New trends and challenges from the Japanese perspective. Springer.
- [10] KUKA Roboter GmbH. (2018). Automation with Industrial Robots. KUKA Publications.