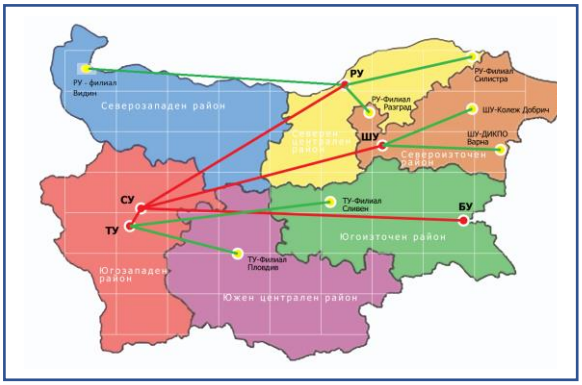
Center of Excellence UNITe

Universities for Science, Informatics and Technologies in e-Society

Contact information:

Website: https://unite-bg.eu



Lead Organisation:

- Sofia University
  "St. Kliment Ohridski"

Partners:

- Technical University of Sofia
- Burgas State University
  "Prof. Dr. Asen Zlatarov"
- University of Ruse "Angel Kanchev"
- University of Shumen "Konstantin Preslavski"
- Center of Excellence UNITe

The Center of Excellence UNITe brings together five leading Bulgarian universities with strong scientific achievements in the field of informatics and ICT, along with the Association COE UNITe.

- Uniqueness: UNITe is Bulgaria's first ICT center with a geographically distributed research infrastructure covering all regions of the country.
- Complexity: UNITe's scientific activities cover all priority areas of ISIS ICT and are aligned with the objectives for regional specialisation and digital transformation.
- Significance: UNITe strives for high scientific achievements in developing tools and services that facilitate the digital economy and society.
- Impact: UNITe's research and innovation activities, involving a large number of stakeholders, contribute to overcoming the digital divide and improving integration into the European Research Area and the Digital Single Market.
- Sustainability: Guaranteed by the partners - leading universities involved in generating knowledge and applying it to prepare the future workforce.

Brief Information About the Center: The UNITe Center of Excellence was established by five universities with high scientific results in the field of informatics and ICT and proven importance for the economy and society in their regions.

Thematic Objective of ISIS to Which the Center is Directed: "Computer Science and ICT"

Vision and Goals: The vision of the UNITe Center is to become a leading Bulgarian organisation in the field of scientific research in "Computer Science and ICT", with a modern distributed research infrastructure covering all Bulgarian regions, attractive to excellent researchers and young talents, well integrated into the European Research Area and widely recognised for its high-quality scientific results and impact on the national and regional economy and society.

The objectives of UNITe are to support the integration and capacity building of partners for cutting-edge research in the field of Informatics and ICT, attract talented researchers and build the next generation of scientists, collaborate with external stakeholders, transfer technology, expand R&I networks with leading European alliances and scientific teams in HPC, big data, AI and other areas, and accelerate the digital economy in society.

Work Package 1: Innovative Mathematical Methods and Models in Support of Digital Transformation

The planned activities aim to create new mathematical methods and models that ensure quality, security and effective means for using data as the basis for the digital transformation of the economy and the public sector. The tasks set focus on the development, evaluation and application of reliable methods for data detection, evaluation, secure storage and transmission, data integration, statistical data analysis and multidimensional data visualisation.

Work Package 2: Data-Oriented AI Applications

The main objective of the planned activities is to solve problems in the field of deep learning (DL), such as: understanding the limitations of large language models (LLMs), their potential to generate absurd or harmful content, understanding why they make certain predictions, why they require significant resources for training, updating and use. The aim of WP2 is to explore the possibilities of using AI approaches for real-world applications and to develop methods and models that are ready for technological development.

Work Package 3: Innovative Methods, Technologies and Tools for Modern Technology-Assisted Learning

The main objective of the planned activities is to explore how adaptive and personalised learning systems can be modified to the pace, style and progress of the learner to provide personalised learning. How to effectively integrate technologies such as VR and AR into TEL to create an interactive learning environment that allows students to explore concepts in three-dimensional spaces, how to easily create and implement educational video games (EVGs) for better learning and reproducibility.

Work Package 4: Bioinformatics – Big Data Processing, Sequencing, Parallel Processing, Prototyping

Creation of new generations of databases for intelligent control and process management, new approaches to the formalisation and extraction of information and its study in large information arrays. The solution for implementing a heterogeneous environment, both at the application programming interface (API) level and at the machine instruction processing (ABI) level, is innovative. Multidisciplinary combination of biology, biotechnology, computer science and information technology for the analysis and interpretation of biological information and opportunities for interpreting large arrays in genetics – DNA, RNA and derivatives.

Work Package 5: 3D Technologies for an Innovative and Sustainable Future, with the University of Ruse "Angel Kanchev" as the Lead Institution

Modern 3D technologies have a strong impact on a wide range of activities and sectors, including the digitisation and visualisation of cultural heritage, manufacturing processes, the creative and entertainment industries, medicine. However, 3D technologies face a number of challenges – many of the current solutions only allow the creation of 3D models of static objects, which hinders the digitisation of processes and movements. This work package explores 3D technologies for digitisation and visualisation, as well as their various applications.

Work Package 6: Smart and Sustainable Systems

The aim of this work package is to develop scientific research and innovation in the field of cyber-physical systems, digital twins and sustainable technologies. The focus is on their application in industry, smart cities and energy management. UNITe is establishing itself as a leading national center for interdisciplinary expertise and partnership in the field of smart and sustainable engineering solutions.

Work Package 7: Cybersecurity and New Methods for Prevention and Protection Against Cyber Attacks

Aimed at developing cutting-edge solutions to protect digital systems, networks and infrastructure from growing cyber threats. The main focus is on intelligent methods based on artificial intelligence, machine learning and the Internet of Things (IoT) for prevention, detection and response to attacks. The team is actively working to create customised solutions for the public and private sectors, including through training and the development of specialised tools.

Services

UNITe partners can provide comprehensive services and pilot solutions, consulting and training in the following areas and directions:

- Digital transformation and process automation: cybersecurity, e-health, smart cities, smart manufacturing, personalised training.
- Digitisation in the public sector: ministries, cultural and educational institutions, and municipalities.
- Artificial intelligence: hybrid AI models, energy efficiency, multimodality, AI for social causes.
- Educational video games and STEM education.
- Genetics and microbiomics: liquid biopsy, NGS, tumour markers, de novo analyses, environmental monitoring.
- High-performance computing: parallel processing, simulations, electronic measurements.
- Prototyping: printed circuit boards, electronics, mechanics, 3D milling and engraving.
- 3D technologies: scanning, modelling, printing, digitisation, reverse engineering.
- Electronic testing and emissions: radio frequency measurements, calibration, harmful emissions.
- EMC and interference: compatibility and signal testing in devices and networks.
- Antenna systems: design and integration.
- Cybersecurity and remote monitoring: audits of embedded systems and IoT solutions.

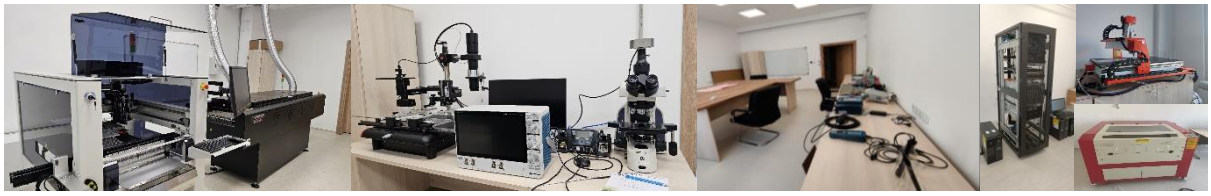
Laboratories and Equipment:

COE UNITe has 18 specialised laboratories, distributed in Sofia (6), Burgas (5), Ruse (5) and Shumen (2).

Laboratories and Equipment – Sofia:

- **Multimedia Content Studio –** Audio equipment: Yamaha TF3 console with microphones and audio accessories. Video equipment: Canon LEGRIA HF G70 UHD 4K video camera, lighting fixtures, etc. for creating and editing multimedia content for UNITe.
- **Robotics Centre at UNITe –** Systems for distributed stream processing and real-time machine learning with technologies such as Apache Kafka, Apache Spark, PyTorch, TensorFlow, JAX, Spring, LangGraph, LlamaIndex, ROS, etc. Use of data from IoT devices and robots, as well as other smart devices (cars, buildings, infrastructure, etc.). Development of robots and IoT devices with integrated algorithms and models for machine learning.
- **"Factories of the Future" Laboratory –** Data center with high-performance server, server infrastructure and workstations, robotic arm/manipulator for automated production processes and collaborative robotics. Wheeled mobile platform robots, digital oscilloscope and digital multimeter with USB interface for real-time testing and analysis of electronic components and systems.
- **Intelligent Cyber-Physical Systems Laboratory –** Vector and spectral analyser for electromagnetic signals, software-defined radio for wireless communication and operation of communication systems in a real environment. Measuring antennas for electromagnetic fields in the field of EMC and radio frequency diagnostics. Anechoic chamber for accurate measurement of electromagnetic parameters.
- **Smart City Laboratory –** Intelligent meteorological station for climate model analysis. Wireless smart lighting control kit. Kits for aerial inspection of buildings (drone, thermal camera, gimbal). Quadcopter (4-wing drone) for testing, aerial surveillance and mapping.
- **Smart Home Laboratory –** Personalised Sleep Solution: Intelligent system for monitoring and improving sleep. Humanoid robot: simulations of human-machine interaction in a home environment, including assistance and social functions. Professional infrared camera for energy diagnostics and safety in the home environment.

Laboratories and Equipment – Burgas:



- **Prototype Laboratory –** CNC router and milling machine, system for mounting and saturating printed circuit boards with components. The system has a conveyor, mounting tower, oven and allows for high-tech prototyping.
- **The "Real-Time Systems, Embedded Systems" Laboratory** has a set of Tektronix 7xxxx and Tektronix 4xxx oscilloscopes equipped with spectral analysers, a system for system and network research, and system measurements for PCIe and network components.
- **The Heterogeneous Architectures and Data Processing Modelling Laboratory** has a parallel system with 1024 cores – INTEL X86_64, combined with ARM modules – AMPERE – 2x128 and QUDA 4x 16491 cores. The parallel structure is unique in the country and allows for optimisation in the implementation of complex computational processes.
- **Bioinformatics and Genetic Research Laboratory – C**omputer infrastructure for the development of algorithms, computational techniques for the analysis and interpretation of biological information. Process modelling, next-generation sequencing (NGS) and real-time PCR, simulation and monitoring of the sequencing process. Development and improvement of adaptive management systems (Schedulers) for multi-core and heterogeneous computing architectures.
- **Real-Time Environmental Monitoring Laboratory –** For real-time water and air monitoring, modelling and optimisation of water treatment processes, assessment of the quality of natural, drinking and waste water.

Laboratories and Equipment – Ruse:

- **Digitalisation and 3D Scanning Laboratory** – 6 high-performance systems, digital photo and video cameras with photo lenses, OptiTrack kinematic capture system with 16 PrimeX22 cameras, Artec Ray and Artec Eva Pro 3D scanners, Artec Leo, Artec Space Spider, Scantech KSCAN-Magic, Scantech iReal 2E, DJI Mavic 2 Enterprise Dual and DJI Mavic 2 Pro unmanned aerial vehicles, specialised software products for 3D modelling, 3D models through photogrammetry and 3D scanning.
- **3D Design and Modelling Laboratory** – 6 high-performance systems, Adobe Substance 3D, Reallusion iClone 8 + Character Creator 4, Marvelous Designer, Geomagic Design X, Pix4Dmapper software packages, as well as HTC Vive VR and HTC Vive Cosmos VR 3D glasses.
- **3D Prototyping and Object Replication Laboratory –** Rayshape DLP Shape1+ Dental 3D printers, Rayshape ShapeCure curing system, Rayshape ShapeWash 020S washing system, Sinterit Lisa X FZ157 3D printer + Sandblaster XL + PHS system, CreatBot PEEK 300 3D printer, Flashforge Creator 4-A HT 3D printer, etc.
- **Serious Games and Simulations Laboratory** – 9 high-performance systems, Sensigent MSEM 160 portable gas monitoring system, CDAnalysis chemometric software, Mind Media BV NeXus-10 MKII physiological signal monitoring system, Contec Medical Systems Co. KT88-3200 EEG signal system, etc.
- **Mixed and Augmented Reality Laboratory** – 2 high-performance systems, Microsoft HoloLens 2 AR/MR glasses, Hologramica Holopops Ultra hologram projection system, zSpace Inspire augmented reality systems, hardware solutions and platforms for content visualisation through augmented and mixed reality solutions and holographic systems**.**

Laboratories and Equipment – Shumen:

- **Development Room with Measuring Equipment and Sensors** (stations for monitoring atmospheric air quality) and Laboratory for 3D modelling and printing.
- **Data Center with Access Terminals –** Module 1 - mathematical foundations of information security; Module 2 - steganographic protection of information and networks; Module 3 - cryptographic protection of communications; and Laboratory for process modelling and simulation.

Participation of the Center in Other Projects

- Member of the EuroCC2 network (33 countries) in the national CC in HPC/HPDA/AI, jointly with the ICT Center at the Bulgarian Academy of Sciences and the CC in ICT (UNWE).
- Created RDA BG node and participation in the international network RDA Europe.4.
- Member of the EOSC Association - Association for an European Open Science Cloud.
- Lead partner EUMaster4HPC, Training and Education on HPC (H2020-JTI-EuroHPC-2020-03).
- OP: National Programme: Integration of Academic Potential in Support of Secondary Education, STEM, Digital Transformation and Science Popularisation.
- Project in support of doctoral students - project BG05SFPR001-3.004-0025-C01 "DUNIZvIKT" Funded by OP "Education" 2021-2027.
- 5GEDGE4HEALTH, OP (Connecting Europe Facility – CEF), Regulation (EU) 2021/1153, Priority axes: 5G and Edge cloud technologies for smart communities, Name of the procedure: CEF-DIG-2023-5GSMARTCOM-EDGE.
- "Improving the competitiveness of SMEs and public organisations in the South-East region of Bulgaria through integrated innovative digital solutions".

List of the Center's Leading Publications and Scientific Results

- During the first phase of the UNITe project, researchers from the center published over 310 publications, 47 of which are in leading Q1-ranked journals.
  Information about the leading publications is available here:
  https://unite-bg.eu/bg/deynosti/nauchni-publikacii/28
- Protected patent: Tzvetomir Vassilev, *Method for lossy image compression using PCA and LZMA*, PCT Patent PCT/BG2023/050003, filed May 10, 2023. Assignee: University of Ruse.