



Rzeczpospolita
Polska



Narodowe Centrum
Badań i Rozwoju



NARODOWE CENTRUM NAUKI

artiq

ARTIQ

**ARTIQ - AI Centres of Excellence
Application for a Host Institution**

Institution

National Centre for Research and Development, National
Science Centre

Project Joint National Project:

ARTIQ – AI Centres of Excellence

Deadline for the submission of applications

8th of April-11th of May 2021

I. HOST INSTITUTION DATA

Identification data of the Host Institution

Name (full)	<i>Warsaw University of Technology</i>
Name (short)	<i>WUT</i>
Name of the main organisational unit (where applicable)	<i>Faculty of Electronics and Information Technology</i>
Address of the registered office	
Street	<i>Pl. Politechniki</i>
Building No.	<i>1</i>
Office No.	
Postal code	<i>00-661</i>
City/district	<i>Warsaw</i>
Post office	<i>Warsaw - Śródmieście</i>
Municipality	<i>Warsaw</i>
County	
Province	<i>Masovian Voivodeship</i>
Correspondence address (if different than the address of the registered office)	
Street	
Building No.	
Office No.	
Postal code	

City/district	
Post office	
Municipality	
County	
Province	
EPUAP [Electronic Platform for Public Administration Services] mailbox	<i>/PW/SkrytkaESP</i>
Legal form	<i>University</i>
The person appointed for contact with NCBR and with the potential Leader/Project Manager	
First name	<i>Jarosław</i>
Last name	<i>Arabas</i>
Position	<i>Director of Institute of Computer Science, Faculty of Electronics and Information Technology, Warsaw University of Technology</i>
Phone number	<i>+48 234 7432, +48 604 683 393</i>
E-mail address	<i>jaroslaw.arabas@pw.edu.pl</i>
The person authorised to represent the applicant	
First name	<i>Mariusz</i>
Last name	<i>Malinowski</i>
Function/Position	<i>Vice-rector for scientific affairs</i>

II. CAPACITY OF THE HOST INSTITUTION TO PERFORM THE PROJECT

1. Description of major research achievements in the scope of implementation of R&D projects, as well as the commercialisation of deliverables of such projects regarding artificial intelligence for the last 5 years prior to or in the year of the application along with a list of the most important publications and patents of the applicant (max. 1 A4 page).

The AI research has a long tradition at Warsaw University of Technology (WUT), to mention only widely recognized works by Professor Zdzisław Pawlak on rough sets. Today, this tradition is continued, research of various kinds (e.g. basic, industrial, development research) and curricula of our faculties include major areas of contemporary AI: machine learning, deep learning, human-like AI, games, security, data, and text mining, logical and statistical reasoning, evolutionary algorithms, metaheuristics, robotics, explainable artificial intelligence, human-oriented machine learning, machine perception (image-, speech- and other sensor-analysis), NLP, computer vision, and bioinformatics.

One of the long-term research directions is *human-like AI*, i.e., intuitive problem solving, creativity, multi-tasking, human-in-the-loop solutions - specifically in the General Game Playing area (co-operation with NTU, Singapore and UNSW, Canberra). Another *human-like AI* research topic refers to modeling human attacker behavior in Security Games, which includes attacker's bounded rationality and its partial observability by the defender - see papers at AAAI'19,'20, AAMAS'19,'20,'21 (cooperation with Harvard University). For more information (FMI): Jacek Mańdziuk (jacek.mandziuk@pw.edu.pl).

We have significant achievements in the field of neural networks. They include designing neural architectures, training algorithms for thereof (e.g. Wawrzyński, ASD+M: Automatic parameter tuning in stochastic optimization and on-line learning, 2017), and applications of neural networks in such areas as computer vision, natural language processing, data analysis, anomaly detection, and others. Researchers of WUT created the most efficient reinforcement learning algorithm (RL) and used it in real robots. FMI: Paweł Wawrzyński (pawel.wawrzynski@pw.edu.pl).

WUT is a leading Polish institution in computer vision research with multiple research projects in this area, e.g., machine learning methods for the ALICE experiment at the Large Hadron Collider at CERN, Low Shot Realistic Human Rendering from Partial Information (Microsoft), Improving the stability of keypoint detection using deep neural networks (Google). Zieba et al. BinGAN: Learning Compact Binary Descriptors with a Regularized GAN, 2018. FMI: Tomasz Trzciński (tomasz.trzcinski@pw.edu.pl).

Our university is active in the field of genetic and evolutionary algorithms (EA) and metaheuristics. We have developed new types of evolutionary algorithms of the differential evolution family. We have applied EA for various tasks, including computer-aided design in mechanics, decision making, automated control. Noteworthy, over the years 1996-2013 we organized annual national conferences on evolutionary computation. FMI: Jarosław Arabas (jaroslaw.arabas@pw.edu.pl).

WUT works on a companion robot, i.e. the application of robots to aiding socially excluded people. As the owner's requirements are virtually limitless, there is a need for specific control systems with variable structures. Zielinski et al, Variable structure robot control systems: the RAPP approach. Robotics and Autonomous Systems, 2017. FMI: Cezary Zielinski (cezary.zielinski@pw.edu.pl)

WUT conducts basic and applied research on explainable and responsible artificial intelligence. In particular, we work on the explainability of models for high-stakes decisions (healthcare, credit scoring). The key results are developing a grammar for a model explanation, developing an exploratory data analysis process, and measuring and improving model fairness. Explanatory Model Analysis. Biecek, Burzykowski (2021). FMI: Przemysław Biecek (przemyslaw.biecek@pw.edu.pl).

We have expertise in developing distributed, scalable algorithms and cloud computing techniques to analyze large-scale genomics datasets (funded by NCN and MNiSW). We test and implement our solutions in the leading medical institutions in Poland—IMiD and WUM, and abroad--ETH, Switzerland; BCM, USA. Wiewiorka et al., SeQuiLa: an elastic, fast and scalable SQL-oriented solution for processing and querying genomic intervals, 2019. FMI: Tomasz Gambin (tomasz.gambin@pw.edu.pl).

We developed and implemented pattern recognition methods with applications in robotics, traffic scene- and surveillance video -analysis, biometrics, and intelligent human-computer interfaces. We participated in SmartItFix, RAPP, RobREx, BIOPKI, BLOWIZ, NPC, APAKT projects. Kasprzak et al.: A hierarchical CSP search for path planning of cooperating self-reconfigurable mobile fixtures, 2014. FMI: Włodzimierz Kasprzak (wlodzimierz.kasprzak@pw.edu.pl)

We have knowledge and experience in software development. We have built dozens of systems using artificial intelligence algorithms and implemented them in production. An example is a system for cancer detection, with a budget of 1.2 MLN PLN, financed by a private company. We analyze biomedical data. Nowak et al, Hybrid de novo whole-genome assembly and annotation of the model tapeworm *Hymenolepis diminuta*, 2019. FMI: Robert Nowak (robert.nowak@pw.edu.pl).

We apply AI algorithms in cybersecurity-related research to analyze events generated by firewalls, intrusion detection/prevention systems. For instance, we developed an eavesdropping detector on the Internet of Radio Light (Horizon 2020) and a steganographic traffic detector (Air Force Office of Scientific Research). M. Gregorczyk et al, Sniffing Detection Based on Network Traffic Probing and Machine Learning, 2020, FMI: Krzysztof Cabaj (krzysztof.cabaj@pw.edu.pl).

2. A list of 5 research and development projects within national and international competitions in the area of artificial intelligence and implemented within the last 5 years prior to or in the year of the application (title, manager, source of financing, amount of financing) (max. 1 A4 page).

In the last five years, Warsaw University of Technology (WUT) cooperated with more than 100 companies and start-ups, implementing hundreds of R&D projects. In 2019, WUT's revenues from the research grants fund by NCN were PLN 22.8 million; by NCBIR: PLN 41.1 million; by EU and foreign institutions: PLN 59.3 million; by industry and business: PLN 40.8 million.

A list of the research project within competitions:

- RENOIR: Reverse Engineering of Social Information Processing. Manager: Prof Janusz Hołys, source: EU Horizon 2020, amount 5.5 MLN PLN
- Machine Learning-based systems for the automation of systematic literature reviews in food safety domain, manager: Prof Radosław Pytlak, source: Norway Grants, amount: 5.2 MLN PLN
- „Simulation and analysis methods of logistics networks for postal operators”, manager: Dr Rafał Biedrzycki, NCBiR, WUT participation 2.6 MLN PLN
- „APAKT - Online child abuse reacting system emphasizing child pornography”, manager: Prof Włodzimierz Kasprzak, NCBiR, 12.3 MLN PLN (WUT participation 2.3 MLN PLN)
- HOMER: Human Oriented autoMated machinE leaRning, manager: Prof Przemysław Biecek, source: NCN, amount: 2.0 MLN PLN;
- NL4XAI: Interactive Natural Language Technology for Explainable Artificial Intelligence, manager at WUT: Prof Katarzyna Budzyska, source: Horizon 2020, amount: 13.0 MLN PLN (WUT participation: 1 MLN PLN);
- Robotic Applications for Delivering Smart User Empowering Applications – RAPP”, manager: Prof Cezary Zieliński, 7th FP EU, amount: 8.0 MLN PLN (WUT part: 1 MLN PLN).

Some projects were not the results of national or international competitions, e.g. Comixify.ai: image processing technology (transfer styles) and the selection of keyframes of the movie, developed as part of the diploma theses at Warsaw University of Technology, commercialized within a start-up that received \$ 500,000 from foreign institutional investors VC. This technology is implemented, among others, by the BBC. Some others are part of large scientific projects, for example, the development of generative models of neural networks for data simulation as part of the ALICE experiment at CERN, or the development of a data fusion engine preventing terrorist attack for the European Defence Agency.

3. Available research equipment, apparatus/infrastructure and intangible assets held in the context of implementation of a project regarding artificial intelligence (max. 1 A4 page).

The Warsaw University of Technology (WUT) is the largest technical university in Poland. For artificial intelligence purposes, we have four server rooms in three buildings, with complete infrastructure.

- Computer cluster for deep-learning calculations and machine-learning and high-performance computing composed of: 3 nodes NVIDIA DGX A100 in the following configurations: CPU: Dual AMD Rome 7742, 128 cores total, GPU: 8x NVIDIA A100 40 GB, RAM: 1 TB, STORAGE: 3,8 TB + 15 TB SSD, GPU Interconnect: 200Gb/s; 1 supercomputer node NVIDIA DGX A100 with 2TB RAM (CPU and GPU as previously), disc matrix DDN SS9012, 1PB with cache DDN AI400X (256 TB), offering 34 GB/s recording speed and 48 GB/s reading; connected by network 100Gb/s.
- Private cloud built on Open Stack and VMware clusters, dedicated for deep-learning, high-performance computing, cybersecurity, and bioinformatics - composed of 34 nodes with (in total) 35 GPUs, 676 CPU cores, 12 TB RAM, 1 PB storage.
- Computing resources not yet integrated with clusters or private cloud, 40 servers, examples: Dell server, 4 x Intel Xeon E7 v3, Tesla K20, 256GB RAM, Dell server 2x Intel Xeon E5, 256GB RAM, Dell PE R720+NVIDIA Tesla K20, Lenovo server 2 x Intel Xeon E5 v4, 384 GB RAM, Dell C4130 2xCPU, 4xGPU NVIDIA P100 (16GB each), 256GB RAM, 4 servers with AMD Ryzen, 4 x RTX 2070 / 2080.
- AR/VR equipment including VR goggles Oculus (10 pcs) Vive, Microsoft Kinect sensors (15 pcs), 3D NextEngine scanner, high-performance GPU-equipped servers for efficient graphics computations (NVIDIA RTX 2080, Titan Pascal and similar), green-box virtual studio with motion capture devices, 3D printers and gimball-equipped drones.

We have robotics, computer graphics, sound laboratories for data acquisitions, and testing artificial intelligence methods.

- Robotics: a two-arm robot Velma with a human-like upper body. The arms are KUKA 7-DoF LWR 4+ torque-controlled manipulators, mounted on an active torso and equipped with a three-fingered BarrettHand gripper. The head is composed of cameras and a Kinect sensor mounted on a 2-DoF pan-tilt neck. The control software follows the in-house elaborated meta-model based on embodied agents enabling automatic code generation resulting in ROS and OROCOS code of the controller. Simulation is done using RViz or Gazebo.
- Machine Perception: A variety of vision sensors is available: RGB cameras in single- and multicamera configurations, RGB-D sensors (Kinect, RealSense), and multiple consumer-grade spherical cameras. A setup is available for collecting 3D models of objects, equipped with a rotary stand, multiple cameras, and industry-grade structured-light sensor. Datasets for object detection and scene analysis were created. Audio signal acquisition equipment includes a multi-channel audio modem "Focusrite Scarlett 18i8 2nd Gen", several high-quality microphones (e.g., Sennheiser MKE 600, AKG CGN 321 STS) and wearing microphones with Wi-Fi connection.

WUT has a strong background in software engineering. Research teams and student teams create software at all levels of technological readiness. We have full pipelines for continuous integration, continuous delivery, our code repositories, and a set of software testing machines. We developed tools for testing software quality, injecting errors, simulating hardware errors. Such tools and such knowledge allow us to apply artificial intelligence methods in various domains.

We closely cooperate with the research groups in electronics, photonics, biomedical engineering, genetics. Such groups work in the same buildings and are strongly oriented into multi/interdisciplinary research connected with artificial intelligence.

4. Facilities or incentives to establish an AI Centre of Excellence in the entity (max. 1 A4 page).

One of the most important incentives to establish an AI Centre of excellence at Warsaw University of Technology (WUT) is the availability of many talented students and PhD students. In 2021, there were 31,000 students. Artificial Intelligence curriculum is offered within computer science studies. It has to be said that computer science studies at WUT are incessantly very popular among high school graduates despite a very high entry threshold. For several decades, the number of candidates to enrol exceeds the number of student positions, at least twice. In the most famous ranking of the Polish technical universities conducted every year by the *Perspektywy* magazine, computer science offered by WUT took 1st place in 2019 and 2020 in the IT cluster. Our graduates regularly win 1st place among employers according to this ranking.

We offer 600 positions in computer science studies every year, for example, master's degree studies (in Polish and in English) with specialization in artificial intelligence methods at the Faculty of Mathematics and Information Science (FMIS), bachelor's degree (engineering) and master's degree studies with a specialization in artificial intelligence at the Faculty of Electronics and Information Technology (FEIT). Each year we graduate about 500 students; for example, computer science in Polish at FEIT--BSc diplomas: 132 in 2020, 108 in 2019 and MSc diplomas: 97 in 2020, 95 in 2019; and for computer science in English: 32 in 2020, 39 in 2019, postgraduate students (big data and data science): 133 diplomas in 2020. Similar numbers of diplomas are issued in computer science at FMIS.

Access to a large group of young and talented people, both students and Ph.D. students, and researchers interested/involved in artificial intelligence will allow us to establish competent and committed dynamic research teams to carry out projects in the prospective AI Excellence Center.

It is important to mention that the status of a Research University was conferred upon WUT by the government (there are 10 such universities in Poland only). This enabled WUT to single out 7 priority research areas, among which there is Artificial Intelligence and Robotics (AIR). For each of those areas, a Research Centre was established. One of the responsibilities of the AIR Centre is the distribution of grants in artificial intelligence and robotics. Other important AIR's responsibilities are integrating AI and robotics research communities, fund mobilization, and organization of research seminars.

5. Other information concerning internationalisation of the entity, foreign scientists employed in this institution, availability of seminars in English, etc. (max. 1 A4 page).

The Warsaw University of Technology (WUT) holds over 120 international academic and research cooperation agreements with universities, research centers and high-tech industries from more than 50 countries.

WUT is a member of ENHANCE alliance (<https://enhanceuniversity.eu>) with six partnerings HEIs: European Technische Universität Berlin, Universitat Politècnica de València, Politecnico Milano, RWTH Aachen University, Norwegian University of Science and Technology, and Chalmers University of Technology. This alliance is focused on science and technology. It offers educational and training opportunities for academic staff and students, such as specialized certified courses, seminars, and research cooperation.

Our University offers 31 complete academic programmes in English, and courses are offered at 15 Faculties – 12 at undergraduate and 19 at the graduate level. It includes master's degree studies in English specializing in Artificial Intelligence at the Faculty of Mathematics and Information Science and Computer Science at the Faculty of Electronics and Information Technology. Doctoral students have several dozen subjects in English in the field of AI at Doctoral School. The University offers invited lectures by representatives of academia and the commercial sector from Europe and overseas. The lectures by the visiting professors are offered as a part of the studies curricula and are also open to the University's academic staff. The highest ratio of international researchers is 30% (Faculty of Administration and Social Sciences).

The students of computer science conducted in Polish are required to speak English at the B2 level. If they did not provide a certificate during recruitment, they must give it in the first years of study. The grade in the English exam is taken into account for the ranking of candidates.

We actively participate in the Erasmus+ programme, supporting staff and students' mobility and academic and research collaboration.

WUT is also a host of numerous international conferences and events in all technology disciplines. WUT organizes annual thematic events and seminars for Ph.D. and postdoc students and staff. Currently, all events are held online.

WUT is undertaking a 6-years-long program "Initiative of excellence – research university" that supports, among others, international cooperation. Specifically, 6 MLN PLN is intended in this program for internships of employees and Ph.D. students in prestigious foreign universities, 6 MLN PLN is intended for foreign professors, postdocs, and PhD students visiting WUT. 1/7 of the above money is by default reserved for artificial intelligence and robotics.

6. Other significant information confirming the experience and resources of the institution (max. 1 A4 page).

The Warsaw University of Technology (WUT) offers its research, educational and institutional potential at the disposal to the ARTIQ initiative and is ready to establish an AI Excellence Center, as a hosting institution.

WUT strongly supports OpenScience. The team of WUT has designed and implemented a Knowledge Base (<http://repo.pw.edu.pl>) that stores information on scientific, research, and implementation works carried out at the Warsaw University of Technology and publications, reports on research conducted with public funds, defended doctoral dissertations, didactic activities, and completed diploma theses. The database is used from 2012 and offers access to full texts, and if this is impossible, then links (DOI, URL) to the source texts. It is one of the largest repositories of this type in Poland.

WUT assists researchers in the areas of activities related to technology transfer and development of cooperation with entrepreneurs to realize their research projects. A team of Patent Attorneys at the Warsaw University of Technology s.c. creates and supervises patent applications. A "Centre for Innovation and Technology Transfer Management of Warsaw University of Technology" encompasses deals with the process of innovation and commercialization. We have an Innovation Incubator (ININ) aiming at the activation of innovative entrepreneurship. We support entrepreneurs, start-ups, and spin-off companies to verify the market readiness of business projects and develop their own companies.

The Centre for Advanced Materials and Technologies lead the WUT contribution to EDIH Mazovia for European Digital Innovation Hubs. EDIH Mazovia is the consortium of four Mazovian institutes of Łukasiewicz Network, WUT, Funding Box and ARP SA. The submitted proposal was accepted at the national level. EDIH Mazovia aims at providing digital services to enterprises. Besides HPC, Cybersecurity and Advanced Digital Skills, Artificial Intelligence is a key technology to be supported by foreseen DIH.

WUT staffers are authorized to access classified projects, and we have a certified secret office. We cooperate closely with NATO and the European Defence Agency.

It is worth mentioning that the WUT Knowledge Base for the keyword artificial intelligence returns the following number of hits: 429 WUT researchers, 3221 publications, and 62 Ph.D. theses, and for the keyword robotic: 40, 218, 15, respectively.