

ARTIFICIAL INTELLIGENCE FOR A GOOD LIFE

Wrocław Metropolitan Area 2021



Artificial Intelligence Wrocław

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“We work together with residents, universities, local companies and corporations. Wrocław is a strong city, the heart and capital of Lower Silesia.”

Jacek Sutryk, Mayor of Wrocław

Wrocław is focused on the development of artificial intelligence (AI). We have human resources, the know-how, specialised companies and institutions needed. The city authorities also support the development and implementation of artificial intelligence.

Wrocław has been a centre of new technologies for the last seventy years. However, it is not easy to list in one place all the companies that base their activities or development on artificial intelligence.

“Wrocław’s search for technological and digital innovations goes back to the 1950s”, says Jacek Sutryk, Mayor of Wrocław. “It is here that the first Polish computer – Odra – was created, here that the Internet was first tested in the eighties, and here that Nasza Klasa, our Polish social network, was born. All this is now paying off. Today, Wrocław is one of the largest clusters of start-ups in Poland. What is more, our city is now in the eighty-eighth place in the world smart city ranking and we are a city with one hundred and ten thousand students, eleven thousand of whom study computer science or related fields of study.

In the prestigious ranking of disciplines created by *Times Higher Education*, computer science and mathematics at the University of Wrocław were listed among the four hundred best faculties in the world while the same disciplines pursued at Wrocław University of Science and Technology – among more than six hundred best faculties.

“We work together with citizens, universities, local companies and corporations. Wrocław is a strong city, the heart and capital of Lower Silesia. The strong Wrocław Metropolitan Area (WMA), inhabited by more than one million people, is the technological and industrial lungs of this organism”, recalls Jacek Sutryk. “This is how we understand the cities, municipalities and counties of the former Wrocław province (a total of forty-four municipalities and eight counties). Our activities and development are based on cooperation in various forms and within the framework of voluntary agreements between local governments. We focus on specific challenges and take a broad view as both Wrocław and Wrocław Metropolitan Area cooperate with partners from Germany and the Czech Republic”.

Let us add the completion of search engine queries, displaying profiled ads in social networks as well as street traffic regulation, drug

Jakub Mazur, Deputy Mayor of Wrocław

production, medical diagnosis support, bots and chatbots in call centres. We already use these elements on a daily basis. Artificial intelligence (AI), machine learning (ML) and working with large information resources – big data – are used everywhere. According to the plans and analyses of Lower Silesian companies, in the next decade, we will see fully autonomous cars, production lines, comprehensive health diagnostics supporting doctors, the monitoring of crops and soils and the autonomous extraction of raw materials in copper mines. The authorities of Wrocław, domestic companies and start-ups as well as branches of large international corporations focus on solutions based on artificial intelligence. They want Wrocław Metropolitan Area to become a technological hub. Lower Silesia has many features that could turn it into a “European Silicon Valley” within a few years: a great international location, perfectly educated young employees, low labour costs compared to Western Europe, research facilities and international contacts.

“If there is a Silicon Valley in Poland, it is in Lower Silesia and Wrocław”, emphasised the experts from the Startup Poland foundation. In its 2019 report entitled *The Polish Tech Scene. 5 Years*, the organisation calculated that there is one start-up per four and a half thousand inhabitants in Lower Silesia. This is the highest density of young technology companies in Poland, higher than in Warsaw. It is estimated that thirty-six thousand people work in the Wrocław IT industry today. The new technology industry is now one of the main pillars of the city’s development.

However, this is not the most essential aspect. Together with Wrocław Metropolitan Area, Wrocław has the opportunity to introduce innovative solutions, which are missing in Western European countries. Why? The best way is to use technological examples. Polish banks leapt over the cheque stage immediately, introducing debit card payments. The telecommunications sector skipped the pagers, which were common in the West, moving subscribers from landlines to cell phones. Now, Wrocław wants to take advantage of the Polish necessity of making a rapid transition to the newest technology by investing in areas related to artificial intelligence, skipping the intermediate stages that are present in Western European countries. Wrocław wants to cooperate with the government in implementing “the Policy for the development of artificial intelligence in Poland from 2020”, which was passed in December 2020 by the Council of Ministers. It will develop projects with foreign partners, especially with Lower Silesia’s neighbour – Saxony. These intentions coincide with the plans of local companies and universities. “Our goal is clear and we will be consistent in achieving it”, says Jakub Mazur, Deputy Mayor of Wrocław. “Together with the metropolitan area, Wrocław has the assets to become one of the leading European centres of using technologies based on the elements of artificial intelligence. We want the conceptual work based on artificial intelligence to be carried out here. Moreover, these are not just “good intentions”. After all, we know the road we are paving. We act!”.

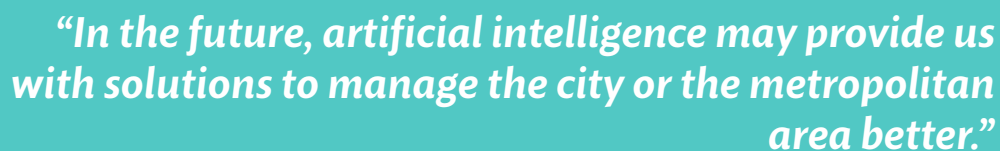
Indeed, the municipality office puts much effort into showing the achievements of Wrocław. However, it also presents the citizens of Wrocław with innovative ideas from a more international environment. To put it differently, it shows what others in Poland and abroad do. To this end, at least two large international seminars on artificial intelligence will be organised every year starting from 2020.

“We support local start-ups and attract companies that declare highly specialised solutions based on artificial intelligence”, says Łukasz Medeksza, deputy director of the Department of Strategy and City Development. “As Wrocław, we will only benefit from this: in the future, artificial intelligence may provide us with solutions that will allow us to manage the city or the metropolitan area better, which is a real gain for all of us”.

As many as eleven thousand people are currently pursuing their studies at Wrocław University of Science and Technology that make use of the potential of artificial intelligence. At the Faculty of Electronics alone, there are five thousand students. This is the largest number of electronics students in Poland. The students are taught by highly qualified research staff. Professor Tomasz Kajdanowicz, head of the Department of Computational Intelligence at Wrocław University of Science and Technology, calculated on the basis of data from the Scopus database that every fifth scientific paper



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authored by Wrocław-based computer scientists is directly related to artificial intelligence. One hundred and thirty-six out of five hundred and sixteen research projects funded by the grants from the National Science Centre that are carried out in Wrocław are related to artificial intelligence.

“I follow academic publications on artificial intelligence in Poland. Based on the data from the last ten years, I can say that Wrocław University of Science and Technology publishes the largest number of papers in the country. In 2020, sixteen universities competed for implementation doctorates in artificial intelligence in the ministerial programme. Seventeen applications with sixty-nine candidates were submitted. Sixteen projects received a positive evaluation, with as many as five of them from Wrocław: four from Wrocław University of Science and Technology and one from Wrocław University of Economics and Business”, says Tomasz Kajdanowicz.

In recent years, several fields of study related to artificial intelligence have been created in Wrocław, mainly at the master's level. So, there are specialists in artificial intelligence educating others. The city has ten large centres engaged in basic and applied research related to artificial neural networks and machine learning. These are primarily Wrocław University of Science and Technology and the University of Wrocław, Wrocław Medical University and the University of Environmental and Life Sciences. In addition, there are the institutes of the Polish Academy of Sciences: the Institute of Low Temperature and Structural Research and the Institute of Immunology and Experimental Therapy.

“I compared the distribution of the so-called impact factor for Poland and Wrocław”, explains Tomasz Kajdanowicz. “Impact factor, the index of citations of publications on artificial intelligence created in Wrocław and in other Polish centres, differs a lot. In Wrocław’s favour. Data analysis shows that scientific papers on artificial intelligence and machine learning produced in Wrocław are better. Moreover, they are published in more prestigious journals than the national average. Therefore, as scientists, we have an advantage over the rest of Poland”.

Artificial intelligence is now an umbrella term – an umbrella that can be spread over numerous applications. Tomasz Kajdanowicz states that the scientific papers on artificial intelligence and machine learning written in Wrocław concern engineering, medicine, physics and astronomy, materials science, linguistics, communication theory and several other areas on almost equal levels. They are, therefore, very diverse. Often, this is not basic research but applied research that is later implemented in industry, frequently within Wrocław Metropolitan Area.

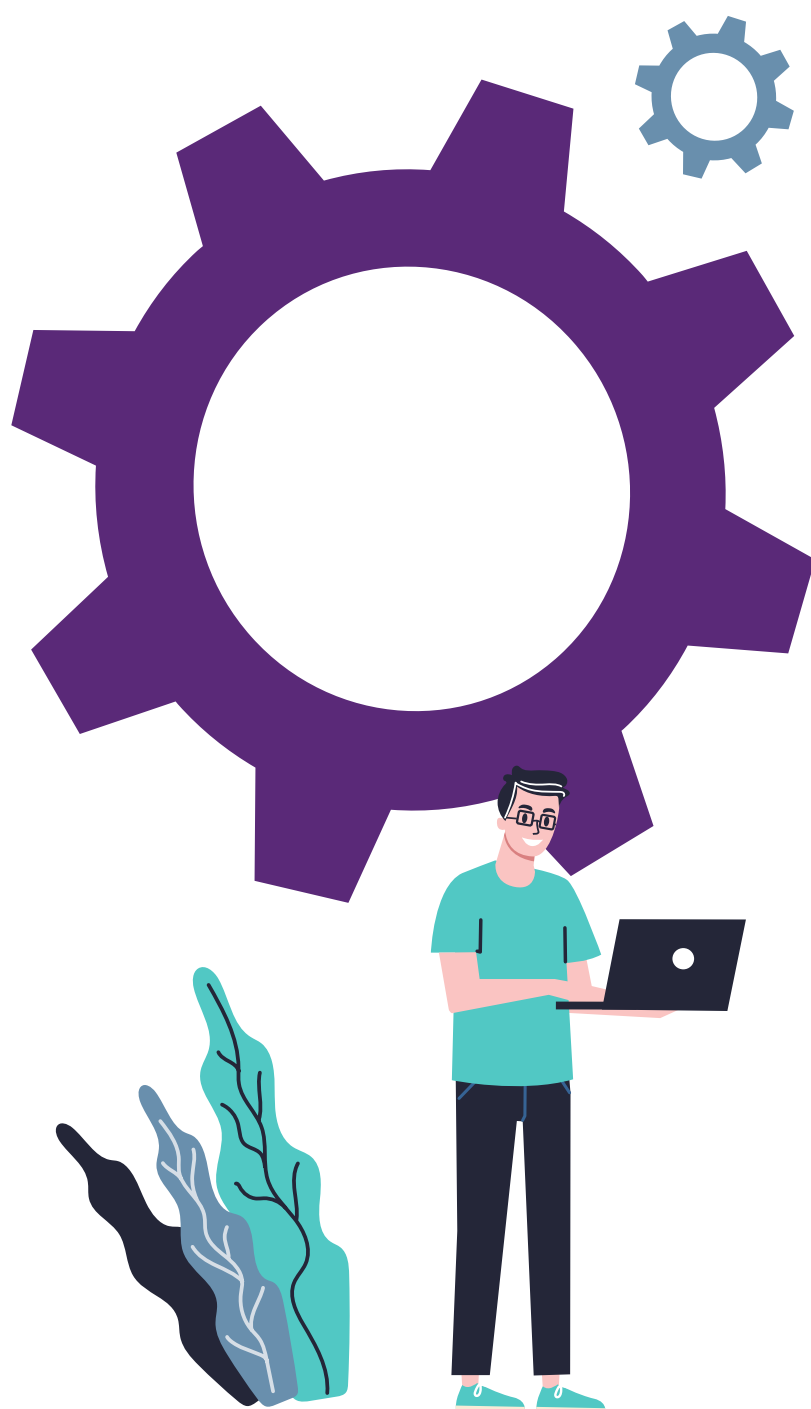
“This is an extremely important feature”, emphasises the scientist. “From the scientific point of view, one can either “research artificial intelligence” or “do research using artificial intelligence”. Today, the global trend is that 90% of patents are about “the applications of artificial intelligence” while only 10% are insights into artificial intelligence itself. The development of artificial intelligence and machine learning occurs when we think of how to use and apply what we already know. Wrocław’s science is pragmatic and diverse. This offers the potential and gives grounds for the conclusion that Wrocław is a great place to develop research and applications of artificial intelligence and machine learning”.

ARTIFICIAL INTELLIGENCE IMPLEMENTATIONS IN WROCŁAW – CASE STUDIES

Every fifth IT specialist in Wrocław implements solutions related to artificial intelligence algorithms or machine learning. Thanks to their flexibility, local companies can celebrate international success. For example, **DataWalk** – a Wrocław-based company listed on Warsaw Stock Exchange – was chosen by the US Department of Justice to cooperate in the fight against money laundering. The platform from the Wrocław-based company, which also works for Poland's General Inspector of Financial Information at the Ministry of Finance, provides investigators and analysts with a complete picture of flows in any currency, including cryptocurrency.

“Our platform easily imports billions of records from many sources and can be used in various areas, including tracking financial transactions. Additionally, it may be used for detecting external and internal fraud, fighting human trafficking or managing pandemics”, explains **Paweł Wieczyński, the company's president, a graduate of Wrocław University of Science and Technology and Wrocław University of Economics and Business.**

The DataWalk platform uses the elements of artificial intelligence and machine learning to automatically complete, clean, overwrite, enrich and analyse data. The created software has proven to be better, faster and more efficient in combining dispersed data than the previous solutions from American companies. As a result, Wrocław residents have founded a company in the United States called DataWalk Inc. The team includes, among others, professionals that can be credited with the success of companies such as Oracle, 3PAR or Visual Analytics as well as former employees of one of the two main competitors of the Poles – IBM i2. The aim of the DataWalk board is to build the first global product in the IT enterprise sector to come from Poland.





“It is about the intellectual potential of students as well as about the implementation possibilities. There are many factories and subsidiaries of global companies in the region”.

Artur Wojewoda from Yaskawa

“We are not the largest city in Poland but this could be our advantage”, says Tomasz Kajdanowicz. “I have spoken to Andrew Ng, a businessman and expert from Silicon Valley, who is the owner of three patents in the field of artificial intelligence. He co-founded Google Brain, was a chief scientist at Baidu, Google’s counterpart in China, and founded the Coursera and DeepLearning AI platforms for massive open online courses taught by universities and research institutes worldwide. He said he would love to set up a subsidiary of one of his companies in Europe. However, he did not want to do it in any capital city because, in his view, capital cities are drained of specialists by big corporations. So, I invited him to join us”.

He would not be the first foreign investor. Business partners have already realised that Wrocław is worth considering when looking for a convenient business location. It is not only about large assembly plants, factories or corporations that are set up in Wrocław or the metropolitan area. It is not surprising that the two largest competing manufacturers of industrial robots, Yaskawa and Fanuc, have located their Polish headquarters in Wrocław.




photo: Robotised painting in Yaskawa company

Artur Wojewoda from Yaskawa explains that his company deliberately chose Wrocław due to the intellectual potential of students and the implementation possibilities. There are many factories and subsidiaries of global companies in the region. Such entities as KGHM are also important.

“Where do robots work? As a rule, they work where it is dangerous, dirty and dull. On the one hand, they work for large mining companies, where it is dirty and dangerous, and, on the other hand, they work for manufacturing companies, where the work is very monotonous. So, who are the ideal customers? The companies willing to implement these solutions”, explains Artur Wojewoda from Yaskawa. It is worth noting that Poland is a country with great development potential. In 2019, we were ranked fourteenth in the world market in terms of robot sales.

Despite the systematic growth of the robot market in Poland, our country is still below the world average (one hundred and thirteenth place in terms of the robotisation density index of the International Federation of Robotics). There are three hundred sixty industrial robots per ten thousand employees in Japan, eight hundred fifty in Korea, three hundred forty in Germany and forty-six in Poland.

Artur Wojewoda reassures: “Research shows that robots will not take away people’s jobs. On the contrary, in countries where the number of automated machines is high, unemployment is low. Companies are retraining workers on production lines into robot operators. The future that awaits us uses the so-called collaborative robots that can work



They will retrain workers on production lines into robot operators. The future that awaits us uses the so-called collaborative robots that can work “side by side” with humans.

“side by side” with humans without pay. The solutions that make direct use of the possibilities of artificial intelligence are to be implemented in the coming years in Lower Silesian factories, as well. The places where, within a few years, machines equipped with artificial neural networks will be working in areas particularly hazardous for people constitute a similar area of dynamic development in the region”.

In countries where the number of automated machines is high, unemployment is low. Companies are themselves retraining workers working on the conveyor belt into robot operators. However, the educational profiles of children and young people in Wrocław are also changing. For example, Lotnicze Zakłady Naukowe secondary school is now a breeding ground for operators of such machines. The future that awaits us is in the collaborative robots that use elements of machine learning.

The citizens of Wrocław design and build robots themselves. The Krab is one and a half metres long and eighty centimetres wide, weighs over one hundred kilograms and can carry a similar weight up a staircase or a steep slope. In addition, it moves on rocky or sandy ground. It is an autonomous walking robot developed by the students and

employees of the **Faculty of Mechanical Engineering of Wrocław University of Science and Technology**. The robot is very durable – even damage to one of its eight legs will not stop it but it will only slow it down. It is to be used mainly in the army (the Ministry of Defence is financing research works). The creators of the robot also want to use it for rescue operations, construction, factory work and transport. The Krab uses 3D scanners and GPS to move in open spaces. Indoors, it scans the space itself and chooses optimal paths of movement.

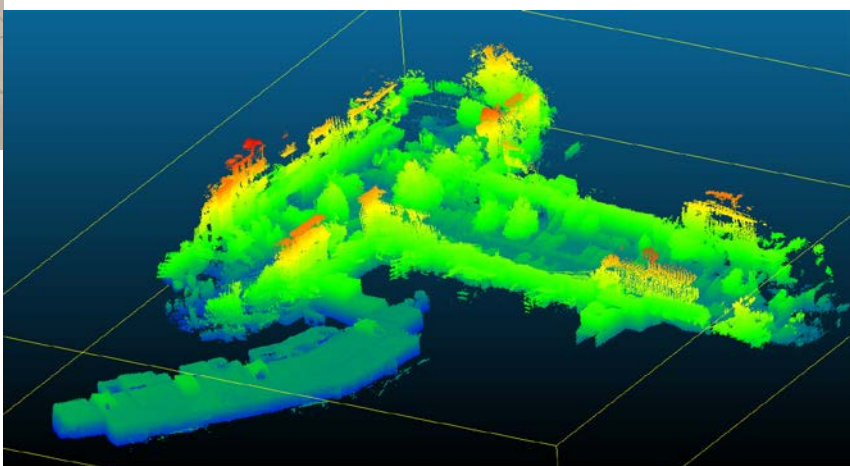
Students from various faculties of Wrocław University of Science and Technology work closely together. **The Krab** could be used as a transport system in a research project to colonise Mars. Students, divided into two groups, designed the Martian colonies “**Twardowsky**” and “**Ideacity**”. In the prestigious Mars Colony Prize, a technological and scientific competition organised by NASA, the projects from Wrocław took the second place and the fifth place, respectively. The teams’ task was to design a self-sufficient Martian colony for a thousand people. The autarkic city produced food, building materials and objects and products necessary for everyday life itself. Controlling the functioning of production processes and life management in the planned centre on the Red Planet would be taken over by artificial intelligence algorithms and robots would perform the tasks based on machine learning algorithms.

“Our entire base is connected to an autonomous network where we collect data in order to use big data tools. This gives us the chance to react quickly when problems arise.



↑photo: Krab – autonomous walking robot developed by the students and employees of the Faculty of Mechanical Engineering.

→ photo: This is how the Krab sees reality.





We can increase our GDP by 2.65 percentage points each year and automate working time by 49% while generating better-paid work. In addition, artificial intelligence will increase the value of Polish technology in the supply chain.

Likewise, data collected by means of artificial intelligence algorithms can help us optimise certain processes such as food production or raw material consumption”, explains **Justyna Pelc from the Ideacity team**. “We have automated the processes of planting, watering, fertilising and harvesting. We use many sensors and a whole video system to monitor their condition. The collected data are processed to make decisions about further actions taken by machines and robots operating the base”.

While the Krab transport robot is a prototype for now, the EuGenius is at a more advanced stage of development. It caused quite a sensation when, as a sixty-kilogram friendly creature with bulging eyes, it greeted travellers at Wrocław’s Central Station. It also showed visitors around museums in Katowice and Kraków and was a waiter in Upper Silesia. The EuGenius robot was designed as a guide for exhibition halls. It was created by a team of engineers from General Robotics, operating in Wrocław Technology Park. General Robotics is a group of specialists in electronics, computer science, automation and mechanics. All of them are graduates of Wrocław universities who have worked on many projects. They have worked on, among other things, the autonomous Agri-bot agricultural tractor and the Mars rover. For now, the machine is controlled by an operator but, ultimately, EuGenius will decide for itself how to conduct a conversation – by reading human emotions from facial expressions or gestures. For this to happen, however, development grants are needed.

Who will fund them? An analysis of the origin of research grants assigned to artificial intelligence research at universities in Wrocław is surprising. Other sources such as investors are twice as generous as the already mentioned National Science Cen-

tre. At the same time, research on artificial intelligence funded by the National Centre for Research and Development accounts for only 3.5% of all projects in the regional capital. This is because Wrocław scientists and companies introducing artificial intelligence solutions do not seek government money but look for it elsewhere.

“I do not see this as a problem but as a positive thing. It is a chance to increase our innovativeness. Wrocław will compete with other cities or regions not only in terms of “cheaper labour” but also in terms of knowledge and modern solutions tailored to the needs of the ordering party. Increasing competitiveness will improve the quality of our citizens’ life. We are already working on this in mixed teams, whose participants are Wrocław universities, the IT sector and members of project teams of foreign companies in Wrocław and Lower Silesia”, explains Jakub Mazur, Deputy Mayor of Wrocław.

The Deputy Mayor calculates that the funds allocated to artificial intelligence by science, business and the government will exponentially grow in the next five years. “We want to “get on that train” and be one of the leaders in Poland and Central and Eastern Europe”, describes Jakub Mazur.

Supporting Wrocław science, local business and local public services in the use of artificial intelligence was announced during the first international seminar on artificial intelligence in Wrocław in February 2020 by **Robert Kroplewski, representative of the Minister of Digitalisation for information society**.

“We see an opportunity to create an important research and application centre for artificial intelligence in Wrocław. It is a strong region where the new technology sector successfully develops. We want to support the

development of particular models of artificial intelligence, e.g. machine learning, augmented reality or digital factories”, claims Robert Kroplewski.

A year later, in February 2021, Robert Kroplewski presented the most important objectives of the government’s strategy for the development of artificial intelligence: “The artificial intelligence policy has been adopted. Why are we implementing it? There are several arguments in favour of AI use. We have the chance to increase our GDP by 2.65% each year. Second, we can automate working time by 49% while generating better-paid work”. The government representative pointed out that artificial intelligence would allow increasing the value of Polish technologies in the supply chain. “Unfortunately, Poles do not trust artificial intelligence very much. Nevertheless, the trend is reversing. The local government that first became intensely involved in the implementation of artificial intelligence policy was Wrocław”.

The representative of the Minister of Digitalisation for information society stated: “We promised that Wrocław and other regional centres would be partners in the digitisation process. Wrocław is a model example here: it looks at artificial intelligence not only locally but municipally, regionally and – finally – internationally and this is important for us in order to develop the Polish potential globally”. **Tomasz Jaworski, director of the digital transformation of the public sector at Microsoft**, looks at Wrocław’s ambitions from a global perspective. He observed and cheers because the company sees a potential for its own development in Wrocław: “Clive Humby, who once invented the Tesco club card, thus revolutionising consumer loyalty programmes, said in 2006: “Today, data are what oil used to be. However, raw data are like unrefined oil; it has the potential but is useless. This is because it has yet to be processed”. In turn, Andrew Ng from Stanford estimates that artificial intelligence will change the world in the same way that electricity once did.

Wrocław’s advantage is its proximity to the border and the resulting German investments in the region, estimated at around

EUR seven billion. For many years, Germany used mainly low- and medium-skilled workers. Since 2015, however, more entities have also moved some of their research centres to Lower Silesia. New production lines are increasingly based on the structures that make use of machine learning functions and artificial intelligence. Dr Lars Gutheil, Director General of the German-Polish Chamber of Industry and Commerce, notes that by 2025, the German government plans to allocate EUR three million for investments in artificial intelligence, intending to build a European artificial intelligence cloud.

Lower Silesia’s excellent location on the border with Saxony already brings benefits. This German state, just like Lower Silesia in Poland, is trying to catch up with the competition from Bavaria or Baden-Württemberg thanks to the necessity of making a rapid transition to the newest technology. Artificial intelligence is to be the remedy for the technological gap: “Saxony has built a network of universities implementing the elements of artificial intelligence in practical solutions in business and industry. Now, we need partners and international cooperation. Therefore, we are looking closely at a natural partner: Wrocław”, explained in Wrocław **Sebastian Gemkow, Minister of Science, Higher Education and Research of the Free State of Saxony**.

There has already been a success in cross-border cooperation. CASUS, or the Centre for Advanced Systems Understanding, was established in Görlitz in 2019. By the end of 2020, the institution already had fifty employees from Poland and Germany. The sponsors for this project were the Helmholtz Research Centres of Dresden, the Max Planck Institute for Molecular Cell Biology and Genetics as well as Dresden University of Technology and the University of Wrocław.

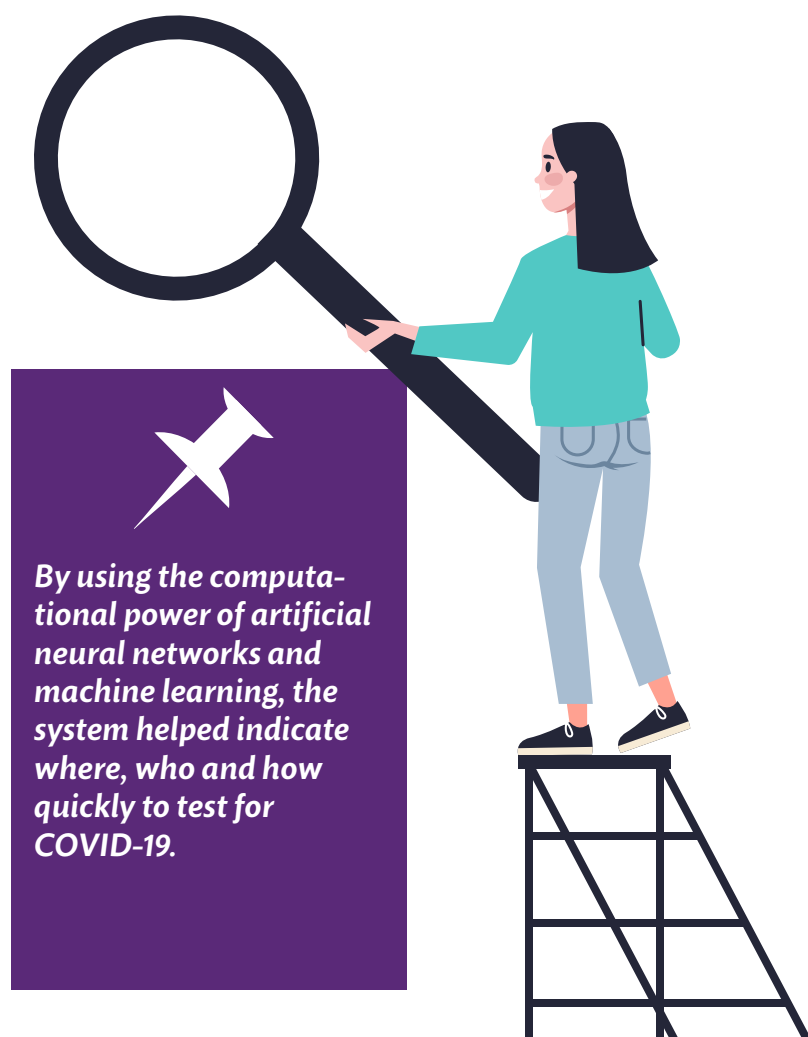
In its projects, CASUS assumes a flexible response to market needs. As Professor **Justin Calabrese of CASUS and the Helmholtz-Zentrum Dresden-Rossendorf laboratory** explains: “Artificial intelligence, international cooperation between scientists and listening to needs is the idea behind the Research Centre in the Europe-City of Görlitz-Zgorzelec”.

The pandemic of 2020 has shown how flexible Wrocław companies and research centres are. The rapid undertaking of research aimed at the application and use of artificial intelligence in order to contain the coronavirus was a test for Wrocław Metropolitan Area. Work on understanding the structure of the coronavirus was already started by, among others, the teams at Wrocław University of Science and Technology and the University of Wrocław in the first weeks of March 2020.

It was also then that the “where2test” project was launched at the CASUS Centre. Using the computational power of artificial neural network and machine learning, the system helped identify where, who and how to test quickly for COVID-19. The solutions developed at CASUS are so universal that they can be applied in the future if another pandemic emerges (modelling of “what if” scenarios). CASUS researchers combine various elements of statistics and medicine. The research team includes data analysts, epidemiologists and online developers. This is science in its most modern form – an international team of researchers from different fields working on the most current issue facing humanity. The result of their work is supposed to provide the answer to fundamental questions both now and in the future:

- What kind of tests should be used (for active infections or antibodies)?
- Where should samples be taken?
- What should the testing look like (first collectively and then individually)?

A parallel example of such collaboration is the original Wrocław-based research group MOCOS, which was awarded the “30 Creative Wrocław Residents” laurel in 2020. **MOCOS** is an acronym for modelling coronavirus spread or data-driven modelling of coronavirus spread. In February 2020, Professor **Tyll Krueger of Wrocław University of Science Technology** urged colleagues to answer the then theoretical question: “What will happen if the



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coronavirus reaches Poland?”. The researchers from Wrocław University of Science and Technology were quickly joined by sociologists from the University of Wrocław and the University of Warsaw as well as foreign researchers from Germany and the Philippines. The idea was to create a virtual model society to predict how the virus would behave and what non-medical measures could be taken to protect from it. The MOCOS model society shows what will change if a quarantine is put in place, how the virus spreads in families and how it spreads in such public spaces as schools and shops. The model looks different if someone is socially active, has a job or is unemployed. What even matters is what kind of job a person has.

“We included many social factors in our model. We even took the distribution of household sizes in Poland into account. In addition, the coronavirus spreads differently at home where we do not wear masks and differently in shops. There is a difference depending on the season and the preventive measures taken”, explains **Marcin Bodych from the Department of Automatic Control, Mechatronics and Control Systems at the Faculty of Electronics of Wrocław University of Science and Technology**. “Our model not only helps to predict how the epidemic will develop in the following days and weeks but it also allows us to understand better the reasons behind the dynamics of virus spread and how it can be prevented. We consult the results with a team of experts at the Ministry of Health. In addition, we are actively participating in discussions of groups modelling the development of epidemic in Germany. A group of scientists in Ilagan, the Philippines, is using our model for risk assessment in their area. We have also developed an application to estimate an individual’s risk of hospitalisation or death due to COVID-19 depending on several factors, such as gender, age and comorbidities. Everyone can use this tool via our website”.

Wrocław’s scientists in agent-based models look for answers to the following essential questions:

- What level of contact tracking is needed to prevent the development of an epidemic?
- What level of contact restriction will prevent the collapse of health care?

At the next stage, the application of artificial intelligence methods will provide an opportunity to refine the model and test different “what if” options.

In the words of Jakub Mazur, Deputy Mayor of Wrocław: “MOCOS is what we are all about: a fast, professional and customised response to the needs of reality. This is our Wrocław success story”.



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We benefit from the scientific potential of Wrocław, from your students and scientists. Your involvement in research on artificial intelligence is of central importance. Each of these companies has built or is building its power and business success on machine learning”.

Neil Pickett,
marketing director of the US

Others have noticed these accomplishments. **Craig Simmons, Mayor of Oxford** – Wrocław's partner city, complimented the Lower Silesians on their creativity, speed and efficiency. Diplomats from the United States emphasise that it is not a coincidence that large American companies such as HP, Google or Amazon have located their headquarters in Wrocław.

"We benefit from the scientific potential of Wrocław, from your students and scientists. Your involvement in research into artificial intelligence is of central importance here. Each of these companies has built or is building its power and business success on machine learning", said **Neil Pickett, marketing director of the US Embassy**.

American companies are not the only ones in Wrocław using artificial intelligence – 40% of large companies located in Wrocław Metropolitan Area are testing such solutions in their production processes or in providing services to their own employees.

Wrocław universities have noticed this interest. For example, Wrocław University of Science and Technology plans to open two new fields of study in 2021: "Artificial Intelligence" and "Trusted Artificial Intelligence Systems".

Professor Izabela Sitkiewicz from the newly established Population Diagnostics Centre at the Łukasiewicz-PORT Institute in Wrocław (Polish Centre for Technology Development) estimates that the practical applications of artificial neural networks are most often present in health care, medicine and finance. Three out of ten systems used for customer or patient service use solutions based on learning systems. In this field, Wrocław is just as good as the world leaders. In addition to testing and laboratory research, the Population Diagnostics Centre will use artificial intelligence algorithms to develop forecasts and expert opinions on diseases of affluence and epidemic threats. Like the MOCOS programme, the Łukasiewicz-PORT Institute will use vast amounts of data and process them accordingly. Machines using automatic learning capabilities will formulate hypotheses and indicate ways to solve problems. Thanks to machine learning, "what if" predictions will be provided. "What if there is a new epidemic in a model country like Poland that...?" is one of the questions posed in the Łukasiewicz-PORT Institute today.



Wrocław is now a major medical research centre with thriving scientific centres: Faculties of Chemistry, Biological Sciences and Biotechnology at the University of Wrocław, the Faculty of Chemistry at Wrocław University of Science and Technology, the Faculty of Pharmacy at Wrocław Medical University and centres of the Polish Academy of Sciences, such as the Institute of Immunology and Experimental Therapy. All these institutions carry out research grants, using self-learning algorithms.

As Izabela Sitkiewicz explains, we could be much further ahead medically today than we currently are if we integrated dispersed databases and gathered knowledge about specific patients in one place. "Let us imagine that not only is the patient standing in front of us but that we have access to the complete documentation of his or her health – the documentation which has already been appropriately analysed: the

essence of knowledge plus the suggestion of answers what can ail the patient. It combines artificial intelligence with big data, with selected information from many areas: all medical records, recommendations, past therapies, insurance, perhaps also information from mobile devices like our phone or smartwatch”.

This last comment – about using “smart watches” in medical diagnostics – is quite justified. **Telemedycyna Polska**, a company based in Katowice and very active in Lower Silesia, is already developing this potential. The information collected by smart watches can be as precise as the indications of specialised hospital equipment.

“More and more studies worldwide prove the effectiveness of popular smartwatches, not only in measuring heart rate or blood saturation but also in detecting atrial fibrillation, diabetes and even ST-segment elevation (which until now was reserved exclusively for hospital ECG equipment). Of course, smartwatches will not replace full diagnostics for a long time. However, these studies show how much power we are already able to utilise in a watch”, describes **Mikołaj Basza from Telemedycyna Polska**. Experts from the Łukasiewicz-PORT Institute and Telemedycyna Polska say the same: it is not only about providing better medical care to Lower Silesian patients. In the near future, the health service will have to make use of remote data transmission and work with the use of artificial intelligence algorithms analysing and grouping data from different sources. Thus, investing in this branch of science and industry will pay off.

It will offer better medical care for residents as well as provide jobs and investments. Therefore, it is worth keeping an eye on it. The World Health Organization data indicate three crucial challenges for medicine in the next thirty years. First, the ageing population (by 2050, the number of people aged sixty and over will have doubled). Second, globally, one point two billion more patients will be in hospital emergency departments. Those beds are already in short supply. Third, we currently have a seven-million-strong shortage of health care workers. By 2030, there will be eighteen million vacancies. We will have to reckon with new diseases and pandemics that will devastate the Earth in express time. Since there is no room in hospitals, people are getting older and there is not enough staff, the solution will be telemedicine. In the United States, due to COVID-19, telemedicine visits increased one hundred seventy-five times in 2020.

"The COVID-19 pandemic has shown how wide the gap is between people who need health care and those who can provide that care. With an ageing population and a growing shortage of health care workers, this gap will widen. The only possible solution to this problem is to move as much of the health care as possible into the patient's home and surround it with smart sensors, credit card-sized wireless EKGs or smart wristbands. Then the data delivered from the patient's home can be analysed using artificial intelligence algorithms to provide the doctor with the most essential information about the patient's condition and support the diagnosis and therapy", describes Mikołaj Basza.



Hospitals already use medical applications embedded in artificial intelligence architecture. As is known, analysers using artificial intelligence are great at reading and interpreting photos and images. Applications to evaluate X-rays are as infallible as good radiologists. No one assumes that machines will replace doctors. However, everyone counts on their support.

MicroscopeIT, a Wrocław-based company founded in 2012, wants to use this potential. The team of scientists and doctors develops machines that effectively recognise histopathological changes in the microscopic images of tissues. The preparation traditionally prepared on a slide and evaluated by a doctor under a microscope is scanned and becomes a digital image. The image, through machine learning, is pre-analysed by artificial intelligence. For the machine to be able to recognise changes, it must “learn” them. This stage is currently underway. MicroscopeIT, thanks to the grant funds from the Horizon 2020 framework programme, is implementing the ExaMode project. Within its framework, it creates Virtum HP – a tool for recognising histopathological changes.

“The first algorithms have already been created. They will classify cancerous areas, initially for colorectal cancer and later also for lung cancer, cervical cancer and even coeliac disease”, says **Edyta Petters, PhD, MicroscopeIT Business Development Director**. For these diseases, there is little work done on algorithms to support histopathologists, especially for prostate cancer and breast cancer while the demand is also high. HP’s Virtum with algorithms will be tested at hospitals in Catania and Nijmegen.

With Catania, Wrocław scientists have been collaborating for a long time. The Sicilian histopathology lab was fully digitised several years ago, one of the first in the world. Thanks to Wrocław’s Virtum platform, doctors were able to work from home during the most difficult period of the COVID-19 pandemic, viewing slides and making annotations as if they had been in the lab.

According to estimates, there are currently four trillion gigabits of diagnostic and biomedical data stored in health care worldwide.



Three out of ten systems used for customer or patient service use solutions based on learning systems. In this field, Wrocław is not far behind the world's champions.

For comparison, one X-ray image is about one gigabit. The amount of data is growing geometrically, doubling every two years. Doctors do not have time to analyse the data reliably. They are unable to review a patient's entire health history. Self-learning apps could do the doctor's job here and present him/her with the result of the analysis. Apps also monitor the patient's condition in real time. They assess how their condition changes. As a result, the hospital staff can focus on those whose performance is deteriorating whereas the rest is looked after by artificial intelligence.

These "intelligent analytical monitoring" functions can also be successfully applied in homes. **Dr Jerzy Sas from the Department of Artificial Intelligence at Wrocław University of Science and Technology** is developing a system of cameras and microphones to be installed in the apartments of the elderly. The program is supposed to learn the typical behaviour of its user and call for help in the case of dangerous anomalies.

Some Polish companies already operate this way. **Diabdis** remotely takes care of three thousand Poles. Another fifty thousand use the application to monitor blood glucose levels and analyse data from the glucometer. Algorithms of artificial intelligence perfectly cope with the analysis of data coming from patients dispersed all over Poland.

"It is worth remembering that diabetes is a civilisation disease. Today in Poland, 9% of the population has to deal with it, that is more than two point eight million people", calculates **Rafał Miozga from Diabdis**. "Data from patients' glucometers are sent to a virtual cloud and analysed by algorithms there. If a problem is identified, the system contacts the patient and orders the intervention of a diabetes educator. If necessary, the specialist can recommend a call with the doctor, who can issue an e-prescription".

After all, three out of four Poles get regular medical consultations from the Google doctor. The search engine generally offers a diagnosis: your symptoms are supposed to mean rhinitis, sinusitis or brain cancer. The result is a terrified patient, further frustrated by their inability to get a specialised medical consultation. This situation is to be changed, with the help of artificial intelligence, by Wrocław-based Infermedica, founded in 2012. Today, it employs over a hundred and twenty people and has branches in the United States and Germany. Its solutions, including the Symptomate application, have already benefited over seven million people globally.

"The user enters the symptoms and the app asks questions to clarify them. It is not a simple "decision tree" but a complex system based on artificial intelligence algorithms built by a team of doctors and data analysis specialists. Our application learns all the time. Forty thousand hours of work by physicians to create a graph linking individual symptoms, risk factors and disease entities are behind us. At the end of the interview, the patient receives one of several recommendations, such as stay at home, consult a doctor (with a specific specialisation) or quickly go to a hospital emergency ward. Our experience shows that 30% of these are the cases that do not require immediate contact with a doctor and their early identification can significantly reduce the workload of health care professionals", explains the head of the company – **Piotr Orzechowski**.

Infermedica shows hard and measurable data. Today, its algorithms have 93% prediagnostic effectiveness and its medical knowledge base contains over seven hundred disease entities and one thousand three hundred symptoms. When asked about the future of his company and medicine, Piotr Orzechowski has no doubts: “Artificial intelligence will not replace doctors but a doctor who uses artificial intelligence will replace the one who does not”.

Infermedica offers its solutions mainly in the B2B model (solutions for companies). Its technology is used by large corporations such as Allianz, Microsoft or PZU Zdrowie. The Wrocław-based company offers applications such as Symptom Checker – a solution that uses machine learning and artificial intelligence algorithms to help hospitals, clinics, insurers, medical and telemedical companies carry out an automatic preliminary medical interview with a patient and recommend the most appropriate medical services. The company has also developed Triage Call Centre – software that supports call centre staff in directing patient traffic based on ailments, pain levels and life-threatening conditions, and Medical API, which allows for the integration with chatbots that accept patient requests or Electronic Medical Records systems that feed the artificial intelligence engine with data previously collected in medical records. The company’s diagnostic platform allows determining an initial diagnosis and identifying the appropriate path for the patient and physician.

As a result, it prevents unnecessary visits that do not require a doctor, shortens the treatment path by directing to the right specialist and sometimes helps identify emergency conditions that could threaten a patient’s life.

An important area which is being looked at by Wrocław scientific centres with the University of Wrocław, Wrocław Medical University, Wrocław University of Environmental and Life Sciences, Wrocław University of Science and Technology and the Institute of Immunology and Experimental Therapy at the forefront is the use of artificial intelligence in creating and producing medications. Today, it takes ten to twelve years to design an active pharmaceutical molecule to release it on the market. The cost of such a process is currently around a billion dollars. Artificial intelligence could speed up this process and reduce costs.

As Professor Izabela Sitkiewicz from Wrocław-based Łukasiewicz-PORT Institute reminds us, we have a growing problem with antibiotic resistance. It is estimated that by 2050, more people will die from untreatable bacterial infections than from cancer. Meanwhile, it is not profitable for drug manufacturers to create new antibiotics because they will not be able to earn back the money put into research for many years as the drug usually ceases to be effective very quickly. The last antibiotics brought to market in the early 21st century were designed in the 1980s. Since then, only a few potential antibiotics have been discovered. Today, new antibacterial drugs are often complex in design. Therefore, the cost of creating them is very high. To reduce such costs and speed up the process of creating a drug, the help of modern technology is needed.

“The answer to the vicious circle of bacteria resistant to the newly produced antibiotics would be artificial intelligence, which can support scientists at different stages of drug design. The first is to design molecules and look for molecular targets for them. The second is to support the study of



“Artificial intelligence will not replace doctors but a doctor who uses artificial intelligence will replace the one who does not..”

Piotr Orzechowski,
Infermedica

manufactured molecules, such as studying molecule interactions and the effects on cells. Artificial intelligence can also help in drug repurposing studies, which is what we are doing now with COVID-19. We do not have time to develop a new drug so we reach for drugs that are registered and on the market and search for their use in other diseases. In this combinatorics, artificial intelligence and its ability to process huge amounts of data may prove decisive. Suffice to say, a new potential antibiotic, halicin, was created thanks to artificial intelligence”, explains Izabela Sitkiewicz. In fact, researchers from Massachusetts Institute of Technology (MIT) used machine learning technology. The artificial intelligence from MIT first underwent special training. It received data on the chemical structure of two and a half thousand substances (mostly registered drugs) and their effectiveness. Then, the details of more than six thousand other chemical compounds were fed into the memory of the artificial neural network. The artificial intelligence selected substances that would act on bacterial strains and their chemical structure would be different from known antibiotics. The most promising compound has been named “halicin” after the intelligent supercomputer HAL-9000 from the movie *2001: A Space Odyssey*.

When will such research also take place in Wrocław? Scientists, especially biotechnologists and chemists from Wrocław universities and the Polish Academy of Sciences, are already working on pharmacological research in international teams.

Wrocław-based professor Adam Maciejczyk, head of the Polish Oncology Society, confirms that “data” are the key to discovering new treatments in the coming years. However, this is sensitive information. Hence, it is essential to develop standards for passing this information to scientists and devices equipped with machine learning functions. Companies and scientists from Wrocław are also working on this.

Professor Marcin Drąg from Wrocław University of Science and Technology, who contributed to working out the enzymatic structure of the coronavirus, admits that he has cooperated and is cooperating with centres from all over the world. However, critical data are never transmitted over the Internet; only standard data are *via* encrypted connections. In turn, Beata Gładysz from DTales, a Wrocław-based company dealing with big data processing, explains that we should structure data collection in medicine: “A one-patient record solution would enable both a comprehensive analysis of a patient’s health condition and the creation of tools for the early diagnosis of various diseases. It would also be a valuable platform for many other research initiatives. Meanwhile, we laboriously digitalise data in disperse systems and patients often only document their medical history in analogue. As a result, although we have all the necessary tools, we still cannot integrate and analyse those data. Therefore, in order to use artificial intelligence, start-ups create various applications to obtain these data or try to establish partnerships with clinics in order to reach patients who will agree to share them. However, this significantly prolongs the time it takes to implement artificial intelligence and thus to reap its enormous benefits. For example, the Polish start-up Genegoggle, which is developing super-innovative cancer treatments, collects differential samples of patients, *i.e.* from a healthy area and a tumour-changed one. It will take at least six years for companies to be able to implement artificial intelligence in medical analyses”.



“We do not have time to develop a new drug so we reach for drugs that are registered and on the market and search for their use in other diseases. In this combinatorics, artificial intelligence and its ability to process huge amounts of data may prove decisive”.

Izabela Sitkiewicz,
Łukaszewicz-PORT

The work with the use of big data and advanced analytics is handled by advisors from PwC, in the company's Wrocław branch. Aleksander Buczkowski from the Drone Powered Solutions team shows the results of a project carried out for a Maltese road agency. There, PwC used drone technology combined with geographic information systems and artificial intelligence algorithms to comprehensively identify the condition and plan the repair/reconstruction of two and a half thousand kilometres of the road.

"In order to plan the reconstruction of roads, an audit of their condition must take place first. Unfortunately, the data the Maltese government had were fragmented. Collecting detailed information on the exact condition of road surfaces in the traditional way would have been expensive, time-consuming and difficult to integrate with other systems. Instead, we used drones that collected precise information (to one and a half centimetres), digitally mapping the entire road network. In total, half a million images were taken during six hundred hours of flight, revealing just nearly two million damages. How do you know how many damages and what kinds of damages? This is thanks to artificial intelligence as algorithms analysed the image data to identify and name the damage to the road surface. The project has also developed an innovative methodology for assessing the condition of roads".

PwC employees jokingly add that the Maltese administrative services have also found out where illegal backyard swimming pools are located, for which the owners have not paid municipal taxes because now the data collected by the drones are integrated into other databases and resources.

Seeing the potential of aerial photography, Wrocław wants to fill the market gap by researching autonomous drones. Therefore, a research cluster has been created in the city – the **Lower Silesian Valley of Autonomous Drones**. A private company named NeuroSpace cooperates with Wrocław University of Science and Technology and the Municipality of Wrocław.

"The uniqueness of our solution lies in the fact that we want to use artificial intelligence and autonomous drones in projects to perform specific tasks. Currently, self-driving drones are a big problem especially when it comes to closed spaces, such as warehouses, where the drone cannot



"PwC has used drone technology combined with geographic information systems and artificial intelligence algorithms to comprehensively identify the condition and plan the repair/reconstruction of two and a half thousand kilometres of the road".

Aleksander Buczkowski,
Drone Powered Solutions



use GPS. We are one of the few regions in the world that develops this type of technology”, says **Janusz Wrobel from NeuroSpace**.

The concept of autonomous drones is just one of the projects of the innovative Wrocław-based Neurosoft company, which has been trying to find different practical applications of machine learning for years. In this case, it deals with the development and implementation of an autonomous system for the precise modelling and monitoring of 3D spatial systems. Wrocław’s autonomous drones should be able to fly around an entire warehouse on their own and collect data on all the products there, using photos and readers.

In Malta, drones were used to check the condition of roads. Meanwhile, Wrocław has used its city buses in a similar way. In autumn 2020, vehicles equipped with smart cameras mounted on the windshield hit the streets. In the pilot project, the public transport company established cooperation with **Karson Technology**, the exclusive distributor of Mobileye in Poland.

“Ten buses have been equipped with intelligent cameras. The system will enable the mapping of road infrastructure and the dynamic marking of pedestrian and cyclist mobility. This solution will improve road safety. The system checks the condition of the roads and reports on the places where repairs are necessary. Additionally, it warns bus drivers of sudden pedestrian encroachment on the

roadway”, explains **Robert Bednarski, a person responsible for SmartCity projects in the Wrocław City Hall**.

Only a few cities in the world use this system, such as New York and Barcelona. Wrocław is the first in Poland.

While Wrocław is testing solutions, others are closely watching these activities. **Klaus Illgmann, the head of the Department for Strategic Development Planning in Munich**, spoke in February 2021 in Wrocław about solutions using artificial intelligence in city management. He cautioned that new solutions could not be introduced without informing residents about their principles. There are more challenges related to artificial intelligence ahead.

“We are preparing new tools but before we use artificial intelligence, we need to learn



Wrocław, ranked eighty-eighth in the ranking of the world’s smartest cities, was rated highest in the “transport and mobility” category (twenty-seventh place in the world)

how to manage data”, said **Klaus Illgmann**. “We collect information from different types of media and we need to develop rules on how and to what extent we can handle these data. Furthermore, each city has its own ecosystem and we need to develop solutions tailored to each specific location and local conditions”.



fot. freepik

The capital city of Lower Silesia has been using the possibilities of artificial intelligence in traffic and communication control for the past five years. Ranked eighty-eighth in the ranking of the world's smartest cities, Wrocław was rated highest in the "transport and mobility" category (twenty-seventh place in the world). It was ranked so high thanks to a coherent traffic control system. The Traffic and Public Transport Management Centre encompasses all the services responsible for traffic in the city: the Road and City Maintenance Management, the staff of the City Engineering Department and the Transport Department as well as the municipal transport operator – MPK Wrocław. They flexibly react to the changing traffic situation, make decisions on actions in the case of accidents, analyse data, plan detours and coordinate the work of road services on the basis of 1285 camera images from 155 intersections in Wrocław.

The city's Intelligent Transport System has been in use since 2014. The multi-component

The multi-component system collects numerical and image data. It consists of cameras, sensors at intersections and in vehicles, bus stop and roadside signs, advanced ICT communication systems and special software.

system collects numerical and image data. It consists of cameras, sensors at intersections and in vehicles, bus stop and roadside signs, advanced ICT communication systems and special software. Using real-time analysis, the system controls traffic lights to ensure optimal traffic flow throughout the city. It also makes it possible to control selected intersections, considering the interconnections between them and the current traffic situation.

In addition, the city has dynamic bus or tram stop information systems – three hundred and sixty boards which provide information on the number of minutes a tram or bus will arrive, traffic changes and air quality. Additionally, almost six hundred and fifty vehicles of the Wrocław transport operator have been equipped with onboard computers and devices for communication with the Intelligent Transport System elements located at intersections. Apart from relieving traffic jams and giving priority to public transport, the appli-

cation supports the process of planning tram track and traction closures. The ongoing development of the system will, among other things, extend the application with algorithms searching the track network in order to find a route avoiding any excluded section, crossing or switch. In addition, it will activate crossing support for city buses queuing due to priority openings for trams. It will also enable traffic control based on mobile data and integrate other transport operators into the system.

The urban information system also includes twelve electronic parking signs and thirteen road signs located at key points in the city, which compare alternative routes in real time. The system uses ARTR number plate recognition cameras and Bluetooth signal receiving devices to assist with measurements. Wrocław's water supplier, Miejskie Przedsiębiorstwo Wodociągów i Kanalizacji, uses the SmartFlow solution. This is a state-of-the-art, algorithm-based IT system that tracks the water distribution process in the water supply network and detects hidden underground leaks. Sensors placed on the water supply network feed the SmartFlow application, which analyses data in the cloud and automatically generates alerts. In the event of an emergency, information about the incident is instantly sent to a dispatcher at MPWiK. In the process, the city saves up to five hundred million litres of water a year and the discovery of a failure has even been reduced from one hundred and eighty days to just seventy-two hours.

Another interesting project is a pilot project by the Wrocław municipality and Microsoft. Special sensors were installed in one hundred and thirty-one municipal waste bins. The sensors send information about overfilling bins, a fire or too high temperatures inside the container, which means that rubbish has started to get spoiled. Batteries inside the bin power the devices. A machine-learning system suggests which bins should be emptied soon. It also indicates where the network of bins should be denser and where some of them can be removed because few people use them.

An IT system that tracks the water distribution process in the water supply network and detects hidden underground leaks.

“As part of smart city projects, the municipality also installs dusk sensors on lamp posts and air quality sensors in city parks”, reminds Jakub Mazur, Deputy Mayor of Wrocław.

Smaller, local companies also cooperate with the city and share their innovative applications of artificial intelligence. For example, the city’s information portal uses chatbots created by the Wrocław-based company KODA Bots. In the first half of 2020, bots answered the residents’ most pressing questions about the coronavirus. At first, Wrocław residents could learn the morbidity statistics in the region and the country and how to protect themselves from the contagion. On the basis of a questionnaire, entrepreneurs obtained infor-

mation on how to receive a subsidy under the financial shield from the Polish Development Fund. The bots offered to the citizens of Wrocław did not operate in the form of a simple “decision tree” but rather as binding graphs based on artificial intelligence algorithms. During the first six months of the chatbot’s operation, more than twelve thousand people were assisted and the number of messages/interactions exchanged between the chatbot and people exceeded one hundred and three thousand. During the conversation with the bot, the inhabitants of Wrocław learned how to get psychological help or spend their free time. They also received a set of answers to the frequently asked questions about the coronavirus and its impact on the functioning of the city, which was “smuggled” into the conversation. The chatbot also provided information on how seniors could go shopping or where to order a meal as part of the #WrocławNaWynos campaign.

“We will continue to develop our chatbot. We are constantly updating its functionalities and checking the frequently asked user questions.



In the first half of 2020, the bots answered residents’ most pressing questions about the coronavirus.



photo: freepik

We are adding new sections of questions and answers. We think that it will accompany us in all the major city campaigns”, says **Krzysztof Szłapka from the press office of Wrocław municipality.**

Wrocław chatbots from KODA Bots previously started operating online for Wrocław Airport, the ZOO as well as commercial clients such as Jeronimo Martins (Biedronka), Komputronik, Limango, TVN24 GO, 4FUN.TV, player.pl platform and large corporations like Accor Hotels, Żywiec, Santander Consumer Bank, UNIQA or Benefit Systems.

After the chatbot proved to be of great help for people in Wrocław looking for information about the coronavirus, the city started to expand its services supported by the virtual advisor. Today, the city’s chatbots are also used to contact residents as part of the “Change the furnace” campaign. During the conversation with the virtual advisor, the resident learns how the furnace replacement programme progresses and how it will be refinanced or financed in their particular case.

In order to teach its bots to converse with customers, KODA Bots has created and is developing a proprietary natural language processing (NLP) system, including a system that supports the processing algorithms in recognising words correctly if they contain errors or there are some missing letters in those words. In turn, the chatbot’s content managers correct the range of recognised words and given answers.

Another Wrocław-based start-up, founded in 2018 by three 25-year-olds, is conquering the real estate market. Their creation is Ada, a platform that increases property sales for developers and agencies with the support of artificial intelligence. Thanks to eighty million metadata from fourteen cities in Poland, a unique system for analysing property offers on the market was created. Ada.place is a neural network that takes into account as many as one hundred and fifty-nine factors – not only price, metric area, number of rooms but also, for example, whether there are shops, restaurants or means of transport nearby.

“We help real estate companies focus on what they do best, which is selling and renting”, says **Kamil Nicieja, co-founder of Ada.place.** “We provide them with technology that they can easily and quickly plug into their website without years of learning about artificial intelligence. Our data allow them to stand out from the crowd by automatically tailoring their offer to each potential buyer, both online and offline”.

A thousand developers have already used the application and, as the company’s creators boast, thanks to Ada.place, properties for PLN two and a half billion have been sold.


DISSEMINATION OF KNOWLEDGE

Imagine looking through a medieval manuscript and then scanning it. After a while, you receive the text saved in a computer word processor. In case of doubt, if the artificial intelligence is unable to decipher the text, you can count on the help of philologists and historians from the University of Wrocław. This is how the latest project of the University of Wrocław – **TransLab** – can be briefly described.

“Based on many texts, the artificial intelligence algorithm engine is to learn how to decode any content visible on a scan and to rewrite it in a computer text editor. TransLab is to be fully functional in three years”, reveals **Tomasz Kalota from the Library of the University of Wrocław**, who is the manager of this unusual project.

What TransLab reads will go to the **Leopoldina.pl** resource – a repository and aggregator of digital texts and images from the database of the University of Wrocław, comprising over twenty-four thousand digitised and disseminated items. Today, they can be accessed digitally from anywhere in the world. Although on a smaller scale, similar resources are being prepared by Wrocław University of Science and Technology in the Azon system – the Atlas of Open Science Resources.

Language and recordings are also being dealt with by Neurosoft, a Wrocław-based company that conducts, among other things, research on autonomous drones. It started working on the Audioscope application with Wrocław University of Science and Technology and the University of Wrocław in 2017. It is a system for the automatic search of content in audio recordings. The developers are building a system for finding short statements in extensive collections of recordings. This is done through an innovative combination of automatic speech recognition technology, natural language analysis and special fuzzy search methods.



During a conversation with the chatbot, the inhabitants of Wrocław learn, among other things, how to get psychological help or how to spend their free time. During the first six months of the chatbot's operation, the chatbot recorded one hundred and three thousand interactions.



“The project is a response to the growing demand for this type of functionality in projects such as e-Protocol (recording of common court hearings) or media monitoring. The system has been carried out in three parallel teams: the University of Wrocław, Wrocław University of Science Technology and Neurosoft”, says **Janusz Wrobel from Neurosoft**.

The work on the design and implementation of the search engine, which will be able to handle large amounts of data (big data) effectively, is very advanced.

The Clarin Language Technology Centre, which deals with the application of statistical and IT methods in natural language research, is much further along in its work. The project has been run at Wrocław University of Science and Technology from the beginning although more than a hundred units cooperate in an international network. Today, Clarin is part of the European natural language processing initiative. More than a dozen tools have been created on the Clarin website, enabling convenient work with large collections of texts. “Unlike commercial search engines, which work with small sets of keywords, Clarin tools try to “understand” the texts they are analysing in their entirety and are therefore able to find information related to the topic of interest to the user, without requiring random typing of different word combinations. This is particularly useful when, for instance, we are looking for connections between selected elements in a very large set of source texts, like persons, places, institutions, enterprises”, explains **Maciej Piasecki, PhD, the creator of Clarin tools**.

Clarin tools support language processing tasks such as automatic text summarisation, searching for proper names and keywords in texts as well as syntactic and morphological

analysis. For example, Clarin is great at showing the current “word of the day” and continuously analyses media discourse and current language trends.

Jan Chorowski, PhD, from the Faculty of Mathematics and Computer Science at the University of Wrocław, has a different approach to language. His professional work with artificial intelligence began with cooperation with Google, where he improved neural models of speech recognition. As he explains, he dreams of computers learning to recognise speech in a natural way.

“Today, when we want to use speech recognition, we need to have hundreds or thousands of hours of recordings transcribed by people. What if we had speech without transcription? Would a computer then learn to recognise speech like a child? After all, a child does not read any transcriptions; it learns language by listening. Will models be able to do the same? I would like machines to be able to learn for themselves. I would like them to perceive the world and be able to build a representation from which they can draw conclusions about the world”, explains Jan Chorowski. This is an innovative concept that can be applied not only when teaching natural language to computers.

“People perceive objects and make assumptions about how a given class of objects will behave. If it is cars, we assume they will stay on the road. If it is pedestrians, we assume they will stay on the pavement or cross that road. We anticipate their movements. I would



“Clarin tools support language processing tasks such as automatic text summarisation, searching for proper names and keywords in texts as well as syntactic and morphological analysis”.

Maciej Piasecki, PhD, the creator of Clarin tools



like to show such scenes to computers and expect them to discover for themselves what these objects are and what they will do”, explains Jan Chorowski.

For the time being, Jan Chorowski is teaching artificial neural networks to recognise handwriting. As training, he provided the algorithms with the ship's logs of the 17th-century Dutch fleet captains exploring Australia and Tasmania. These data are not described anywhere on the web. The question is whether the algorithms, comparing tens of gigabytes of other texts, will be able to understand what they are dealing with.

In turn, **Nokia's Wrocław branch** cooperates intensively with the University of Wrocław, giving lectures to students on the application and implementation of machine learning and artificial neural networks in telecommunications. The company has also launched Nokia Garage. This is nearly five hundred square metres of creative work space for innovators. The engaged community consisting of the company's experts as well as scientists, students, IT enthusiasts and business partners have access to the most advanced technologies, including solutions from the area of machine learning, artificial intelligence and 5G. Seeing Wrocław's potential, the company is developing a research and development centre where engineers work on software based on machine learning codes for telecommunications systems.

According to a report by the Centre for Information Processing – National Research Institute, three out of four scientists involved in artificial intelligence believe it will be a blessing. This opinion is shared by 41% of scientists from

other fields. However, scientists *do* see risks: 82% cited the risk of surveillance of citizens by the state and three quarters fear a restriction of privacy by companies using artificial intelligence. The problem of the increasing levels of digital exclusion and lack of transparency of decisions made by algorithms was noted by nearly 60% of respondents.

Scientists from Wrocław also address the issue of application and responsibility for the actions of artificial intelligence. **Professor Jacek Gołaczyński of the University of Wrocław** investigates the possibility of creating a new civil law entity in terms of artificial intelligence systems. There is a social conviction that artificial intelligence is something intermediate between a civil law entity that corresponds to physically existing persons and a contractual creation, such as a legal person. In the latter case, it is not a real existing person but an organisational unit.

“From the legal point of view, there is not much of a difference between a legal person as a certain convention and as artificial intelligence. The fundamental difference only arises in connection to liability. In the case of legal persons (for example, corporations), there is ultimately liability on the side of real people representing the entity. However, who would be responsible for artificial intelligence? The manufacturer? The user? There is no clear answer to this question”, Jacek Gołaczyński describes his research.

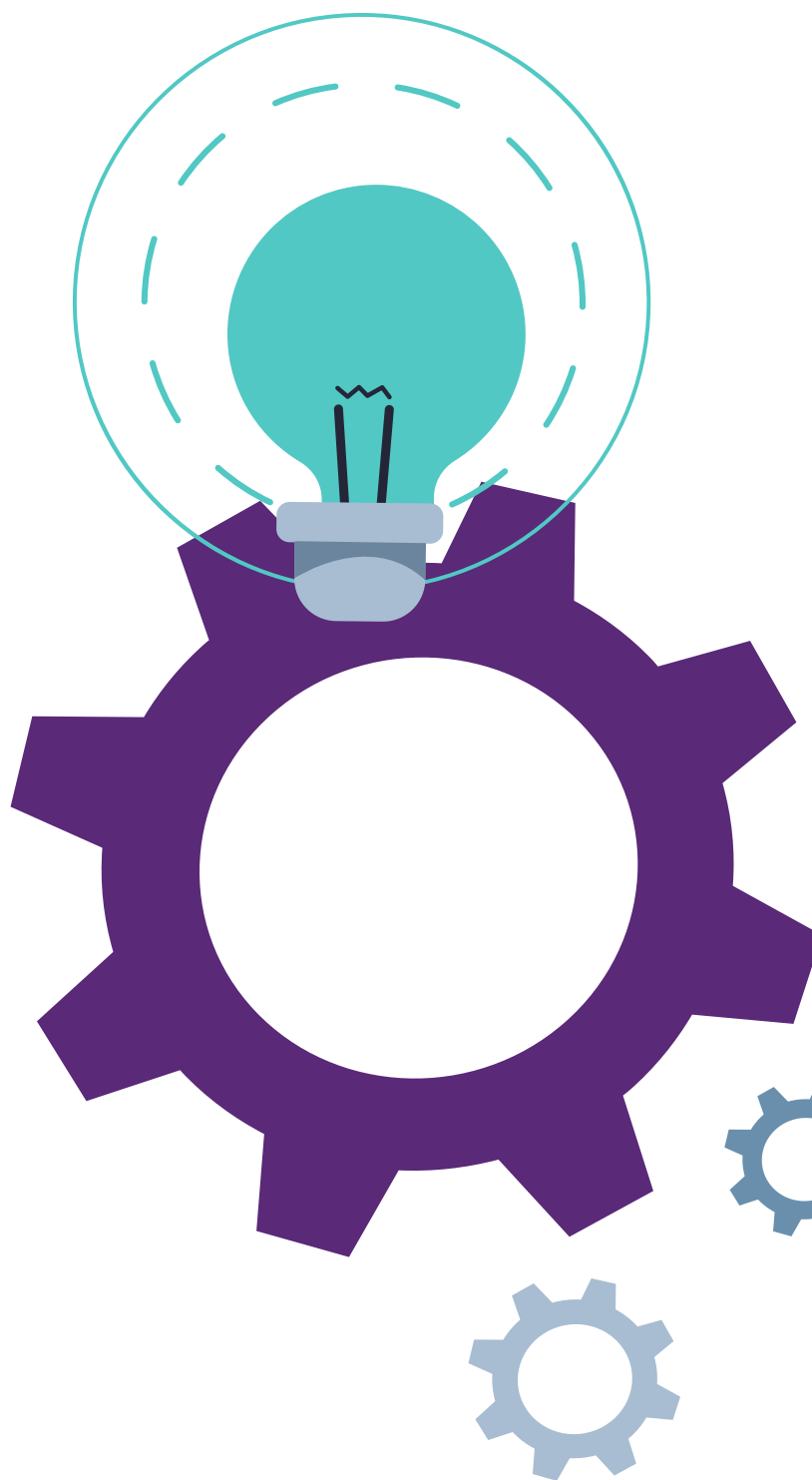
By 2022, three-quarters of organisations in Europe will be using artificial intelligence for customer service, according to reports from MIT and IFS software company (Plans to implement artificial intelligence technology and prepare businesses for disruptive change in operations).



WROCLAW METROPOLITAN AREA

Wrocław is aware of its strengths and weaknesses. Wrocław's strength is its large intellectual and scientific potential while its weakness is its size – a city of six hundred thousand inhabitants is too small for large projects. However, twice as populous as Wrocław, Wrocław Metropolitan Area is not too small. That is why the city not only builds research centres, such as CASUS in Görlitz, but also cooperates extensively with companies located within a radius of several dozen kilometres from Wrocław through Wrocław Agglomeration Development Agency.

The city benefits from the potential offered by strong scientific and research centres. **Professor Tomasz Kajdanowicz of Wrocław University of Science and Technology** shows an example of how science, the city and artificial intelligence can be combined: "We analysed social media posts about public transport in Wrocław, using artificial intelligence. Thanks to this, we were able to suggest changes to the Municipal Transport Company: where a stop should be located, where the tram should wait longer at the stop and where the tracks need to be repaired". The computer scientist from Wrocław University of Science and Technology stresses that Wrocław is an open city and absorbs ideas related to the development and implementation of artificial intelligence like a sponge. The local government, which makes data available for the benefit of the inhabitants, is open-minded, as are scientists who can use these data and entrepreneurs who can commercialise their ideas. Furthermore, the social climate shows that the citizens of Wrocław themselves are interested in the transformation of the city that may take place as a result of applying artificial intelligence algorithms in the management of Wrocław and Wrocław Metropolitan Area.



As Łukasz Medeksza from the Department of Strategy and City Development explains, city authorities aim at the integration on several levels – the city wants to improve the quality of its e-services and integrate them significantly. This also concerns data and ways of making them available.

“Collecting data is not enough. It is necessary to use them, interpret them and draw conclusions for the inhabitants and for city management. In order to interpret this amount of data in a sensible way, we may need support from learning machines based on artificial intelligence algorithms in the future, which also work on big data”, says Łukasz Medeksza. The city is intensively discussing cooperation and integration with the twenty-seven neighbouring municipalities and with seven counties. The idea is not to think of Wrocław as a city of six hundred thousand inhabitants but as an agglomeration of one million two hundred thousand – Wrocław Metropolitan Area. It is not about shifting administrative boundaries but about making communication more common. This means combining the availability of Park&Ride facilities, an agglomeration ticket, identical fares for different carriers and an appropriate number and quality of public transport routes. For such a combination to succeed, artificial neural networks will be needed early on, for example, for managing and integrating databases.

“The potential for using artificial intelligence is enormous, such as in the work of local governments, in the modelling of spatial processes. Let us take our system supporting traffic management as an example. It has been in operation for a decade. It generates huge amounts of data. With the use of artificial intelligence, we could use these systems further. There are a lot of possible applications”, describes Łukasz Medeksza.

In Jawor, **Mercedes-Benz** is building a factory of batteries for its electric cars. **Volvo's** electric buses are built in Wrocław, **Toyota's** hybrid buses are built in Wałbrzych and Jelcz. Both Wrocław Metropolitan Area and the whole of Lower Silesia are essential areas for the automotive industry and leading companies in this sector are already implementing

solutions based on artificial intelligence.

“Applications of artificial intelligence in cities include automatic parking and modern telematics solutions. Artificial intelligence is also an element of Industry 4.0. In this area, Mercedes-Benz Manufacturing Poland is already cooperating with a start-up from Wrocław. Autonomous driving is already being tested in many countries, with Mercedes autonomous taxis (in cooperation with Bosch) already operating from San Jose airport in the US to the city centre. There is no reason why such a solution should not also be introduced in Wrocław one day. All these solutions improve road safety and health by reducing emissions of carbon dioxide and harmful particulates”, points out **Ewa Łabno-Falęcka, PhD, from Mercedes-Benz Polska.**

Companies near Wrocław are ideal recipients and testers of ideas and products created in Wrocław start-ups and universities. Polkowice-based **CCC** company is a good example. You can choose the brand of shoes, their colour and size by talking to a voice assistant. Or take a picture of a shoe in a competitor's shop and find a similar product in CCC with the help of the app. In shops where many brands are sold, the basic problem was different sizes between brands. Thanks to scanners placed in shoe shops or the help of an online chatbot, customers could check what size would be best for them when buying a particular model of footwear.

According to reports by MIT and IFS software company (Plans to implement artificial intelligence technology and prepare businesses for disruptive change in operations), by 2022, three-quarters of organisations in Europe will be using artificial intelligence for customer service. The number of companies reaching for such solutions to manage employees' work or delegate tasks will triple. Every second company will use the elements of artificial neural network systems in their management or production procedures. Similar declarations also come from the enterprises operating in Wrocław Metropolitan Area.

SUMMARY

An important element of the three seminars on artificial intelligence held in Wrocław was panel debates with representatives from public administration, science and business. They were led by **Dionizy Smoleń – Director in the Public Sector and Infrastructure Team at PwC**.

“According to the participants of the debates, it is access to data that is the key to develop artificial intelligence further today. However, this is coupled with a concern – will the data be safe? Unfortunately, we have examples from the world of their fraudulent use. Therefore, for artificial intelligence to develop, a clear legal framework is needed to guarantee data security. It is not without significance to sort out the ethical issues regarding what artificial intelligence is and what it is not”.

According to experts, there are a lot of data but we are unable to use them, combine them or reduce them to a common denominator.

“At this point, it is worth emphasising the efforts of Wrocław to use the already available data within Wrocław Metropolitan Area. Building a common, coherent ecosystem is of key importance in any space and Wrocław itself is becoming an important research centre on artificial intelligence”, believes Dionizy Smoleń. “The key to the further development of artificial intelligence is cooperation based on trust among the worlds of science, business and public administration. For example, business needs public administration to define the expectations and needs of service recipients, i.e. the inhabitants. Scientists count on business support in educating personnel in the field of artificial intelligence. It is about, for example, commissioned university courses or support in teaching. On the other hand, public administration needs help in attracting new personnel to be able to implement innovative solutions”.

According to Jakub Mazur, Deputy Mayor of Wrocław, the city focuses on cooperation in the triangle of mutual dependence: business-science-city. “For years, Wrocław municipality has been aiming at creating conditions for a knowledge-based economy. Small companies, start-ups as well as large corporations benefit from it. They test their solutions in Wrocław and in the entire agglomeration. In addition, we have very ambitious universities. They are not the world’s top yet but Wrocław universities are aspiring, with something to prove, led by rectors who are ambitious and willing to introduce changes”, describes Jakub Mazur.

Jakub Mazur often uses the metaphor of a speeding train that Wrocław wants to jump on. This is how the city understands investments in artificial intelligence. The city authorities hope that this positive attitude will attract research and development companies which, together with universities, will for example, benefit from the EU money guaranteed for implementation. A report by the European Commission (ESPAS, Global trends to 2030: is the European Union able to meet future challenges?) indicates that by 2030, 70% of companies will be using solutions that make use of artificial intelligence to some extent. Hence, the increasingly strong international cooperation to catch the technological train, as is happening with Wrocław-Saxony CASUS project. The research centre located on the border, in Görlitz, is also an answer to Wrocław’s needs:

“As a city, we need to know more. I emphasise: to know, not to guess. Today we cannot afford intuitive choices”, explains Jakub Mazur. “When we pay public money for something, we have to be sure that it is honestly spent. We count on and even demand research, modelling and testing from Wrocław companies and universities. All this is often possible only with the use of artificial intelligence algorithms. A good example here is MOCOS, a group of researchers who have created a model society in order to forecast, on the basis of this virtual data, how the coronavirus pandemic will develop in the real world”.

Professor Tomasz Kajdanowicz, a specialist in data analysis, adds one more link to the three main actors of action identified by Jakub Mazur: “I call it the “four Ps”. The connection: P – like the mayor (in Polish called “prezydent”), who generates needs, P – like the CEO (also called “president”), for example, of the company that will satisfy these needs. With this, the city will create conditions for testing proposed solutions and companies will test these projects in Wrocław for free on a living urban organism. Another P is the professor because someone has to bring the solutions. However, I will leave the most essential P for the end – it is the participant, the resident of Wrocław, whose life should be better, easier and healthier. This is what artificial intelligence is for: it has an exclusively utilitarian function.

The city and its institutions are bridges between businesses, start-ups, IT community, universities, Wrocław Metropolitan Area and potential investors. An ongoing dialogue between these ecosystems is important and it is nurtured. Hence, the periodically organised conferences, meet-ups and symposiums presenting Wrocław companies, the technological ecosystem, emerging ideas and implementations.

“Wrocław was noted as the eighty-eighth city out of a thousand the so-called smart cities. This confirms that the actions we have taken, among others, in the field of urban infrastructure, have proven to be successful”, emphasises Jakub Mazur, Deputy Mayor of Wrocław.

Wrocław consistently builds its image as a technological hub in Poland and abroad. Independent rankings, such as the Spanish Centre for Globalization and Strategy IESE smart city, show a high and improving quality of life in the city and the municipality itself consistently implements or tests new solutions. A cheap and well-organised office and coworking space and large research centres, such as universities and development centres (Łukasiewicz-PORT Institute or Wrocław Technology Park) are also significant. Joint and interlocking projects are facilitated by large Wrocław Metropolitan Area, having more than a million inhabitants, and – at the same time – a compact and well-connected city internally and externally with an expanding airport.

Wrocław sees itself as an IT-friendly space, with implementations based on machine learning and artificial intelligence. The city authorities not only attract and support companies involved in these technological aspects but they also test some of the projects themselves for their own purposes and for the convenience of Wrocław residents. Start-ups and innovators present their ideas on the agglomeration and national forum. They are eager to get in touch with potential investors, including foreign

ones. Hence, among other things, there was the idea of organising international seminars which took place three times during a year despite the pandemic: in February and September 2020 and in February 2021. These meetings also show the growing importance of Wrocław. While the first meeting focused on the presentation of local companies and start-ups, the expert line-up was already decidedly international at the last meeting and Wrocław compared its solutions with the ideas of world leaders in the use of artificial intelligence.

“I believe that we are on the right track to becoming a leader in artificial intelligence in Europe and thus attracting investors”, concludes Jakub Mazur, Deputy Mayor of Wrocław. “My dream is for Wrocław to become a truly intelligent city; a city that will not only meet all the needs of its inhabitants but, thanks to artificial intelligence implementations, will also be able to predict and anticipate them”.



In 2016, South Korea's Lee Sedol sat down to duel the world's most difficult puzzle game, GO, against the AlphaGo computer created by Microsoft. The professional player lost 1:4. Previously, at the turn of the 20th and 21st centuries, successive chess grandmasters had to acknowledge the superiority of the computer. Lee Sedol's loss was the final straw in man-machine duels. Since then, humanity has had no chance of beating a computer at one game or another. However, the point is not to fight with the computer but to use the superhuman potential of artificial neural networks for human purposes. This is the philosophy of many Wrocław companies and the city itself.

Ranked eighty-eighth in the world smart city ranking, Wrocław undoubtedly wants to be one of the leading players in the research on the practical application of artificial intelligence as well the global implementation of AI. Moreover, it has strong arguments for doing so.

Wrocław Metropolitan Area 2021