ROBOTICS BUSINESS REVIEW

WHITEPAPER

How to Start Your Robotics Career

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GETTING A HEAD START ON FINDING A NEW ROBOTICS CAREER

An overview of the education, skills, and types of jobs that are coming in the robotics arena.

By Andrew Williams

As the robotics industry continues to expand and diversify, the number of potential career paths open to students and new entrants to the employment market - as well as to those people seeking to switch jobs mid-career - is growing exponentially. From electronic and mechanical engineering to machine learning, automation and cybernetics to artificial intelligence, autonomous vehicles and drones to space technology, the amount of options available is vast.

A recent study by global professional services company KPMG also confirms the amount of robotics sector jobs available to workers will rise in the coming years. The study states 95% of 138 U.S. technology industry CEOs from Internet, hardware, software, IT service and cloud companies quizzed about the relationship between human and robotic labor predict an increase in their human workforce, in spite of a rise in the use of automation technologies.

Growing interest in the pursuit of a robotics career is a global phenomenon, with students and job seekers in both developed and developing countries clamoring for positions. For example, the job search platform Indeed recently reported a 186% rise in the number of people searching for opportunities in the robotics sector in India between May 2015 and May 2018 - and revealed that amount of job postings in the sector increased by an impressive 191% over the same period.

Throughout this whitepaper, we'll take a closer look at some of the skills people starting out on a robotics career might need - as well as the competencies likely to be in demand by companies across the sector in the coming years. We'll also review some of the leading institutions and programs - and take a closer look at what a day in the life of a robotics expert might entail.

GETTING STARTED - MAKING SENSE OF THE ROBOTICS SECTOR

A recent high-profile report by the influential Economist Intelligence Unit (EIU) stated the emergence of a world characterized by the automation of routine

tasks will require schools to instruct students in the range of skills that software and machines still find difficult to replicate. In addition, schools will need to equip students with a solid grasp of technical skills, such as computational thinking, and an "understanding of AI techniques and robotics."

In addition to basic digital skills such as coding, as well as a thorough grounding in STEM subjects, the report The Automation Readiness Index: Who is Ready for the Coming Wave of Automation? also reveals that "soft skills", including critical thinking, communication, collaboration, and creativity, are likely to be increasingly required in the future automated workplace.

A recent analysis by education expert Beverley Lerch also supports these findings, and reveals that a robotics education can benefit students in several key ways. For example, since many robotics courses simultaneously incorporate creativity and fun into tasks, this encourages the development of creative thinking.

"Students love to partake in activities in which they have full control, something that is possible with robotics," said Lerch. "And when learners are able to do cool stuff, they want to develop more features."

Lerch said such courses also encourage engagement in hands-on learning activities, which help enhance a student's concentration and attention level, preparing them to cope with rapid advances in fields as diverse as artificial intelligence, autonomous vehicles, and space technology.

KEY SKILLS AND COMPETENCIES

Although the amount of options available to people thinking of embarking on a career in robotics are complex - and sometimes even bewildering - it is possible to identify several key skills and competencies that will benefit new entrants, whichever path they choose.

Electronic engineering and computer science skills are two key skills when embarking on a career in robotics and AI, said Professor Ronan Farrell, senior lecturer in electronic engineering at Maynooth University, in Ireland. However, he also said that many of the greatest challenges are "less in the area of technical skills but more in the area of policy, decision making, logic, and ethics."

"From that perspective, I would encourage students interested in AI to look at their engineering and computer science, but also to try to have as broad a perspective as possible - sociology and philosophy are excellent topics. This is

Credit: Volkswagen

Johannes Teiwes, Volkswagen

true for secondary school, and university," he said.

Johannes Teiwes, a robotics expert at the Volkswagen Group's IT Smart Production Lab, advises those starting out in a robotics career to begin by obtaining a "sound knowledge of operating systems, programming languages, and a basic understanding of logic and mathematics" before gaining extensive hands-on experience.

"Finally, never stop developing creative and maybe crazy ideas and try to pursue their implementation," Teiwes said.

Rose Luckin, professor of Learner Centered Design at University College London's Knowledge Lab, said the most important thing is to have the right mindset when cultivating a career in AI.

"You need to be resilient, good at problem solving and always learning," said Luckin. "At the moment, people often restrict their views about AI to being about Machine Learning, but AI is really about Intelligence and about how to develop computers that can behave intelligently."

Luckin, once described as the "Doctor Who of AI" in The Seldon List 2017, is a major figure in the British education system. "[AI] is interdisciplinary, so having an interest in arts and science is an advantage. Not all AI careers are about working on your own, in fact most involve working as part of a team, so being able to communicate effectively and work collaboratively are also important," she said.

WHAT SKILLS ARE BUSINESSES LOOKING FOR?

In addition to developing the range of basic skills necessary for a robotics career, students and career switchers should also keep a close eye on the ever-evolving demands of companies operating in the sector.

For example, from an electronic engineering perspective, Maynooth University's Farrell predicts that future robotics applications will be characterized by "increasing combinations of hardware and computer systems [that have] the ability to sense and interact with the environment."

"The feeling of touch, sound and pressure ... all of these need to be captured and interpreted," said Farrell. "A good example is a robot hand. The human hand has heat, touch and pressure sensors in every part of the skin. This gives huge sensitivity and adaptability to our hands," he said.

"People who can analyze complex problems and develop solutions that use a blend of human and artificial intelligence will be in demand."

— Rose Luckin, University College London

Although the best robot hands currently have between 30 to 100 sensors in different spots, Farrell said there is "no comparison in the level of capabilities between the two," and connectors between existing robots and the outside world remain "very crude."

"As this improves, new options become available and new businesses become accessible," said Farrell. "For robots to properly interact with people and fragile objects, we will need this," especially for robots involved in health care and home care.

In the AI sector, Luckin said there will be an increasing recognition that machine learning as AI can "only get us so far", with an "increased need for people who can embrace the fuller AI agenda," such as those with interdisciplinary interests and backgrounds.

"People who can analyze complex problems and develop solutions that use a blend of human and artificial intelligence will be in demand," Luckin said. "As AI evolves, the skills people will need will also evolve, hence why people need to be keen to learn and they need to accept that they will always need to learn. There is also likely to be an increase in the demand for people who understand the complex ethical challenges that AI poses."

A SAMPLING OF LEADING INSTITUTIONS AND NEW OFFERINGS

Because the robotics landscape is vast and growing, it would be nearly impossible to list all of the programs and higher education institutions worldwide that offer robotics education. Below is a chart listing a sampling of some of the leading institutions, along with links for more information about their programs.

University/Institution	Country/Location	Brief description	Website
University of Bonn (Hochschule Bonn-Rhein-Sieg)	Bonn, Germany	The English-language MSc program in Autonomous Systems is billed as the first Master's degree course dealing with autonomous systems in Germany, and is run by "globally recognized robotics experts."	https://www.h-brs.de/en/inf/autonomous-systems-msc
Brandeis University	Waltham, Mass.	The Graduate Professional Studies division recently launched an online, part-time Master's of Science in Robotic Software Engineering. In addition to providing students with a firm grounding in subjects like Modern C++ and Robotics Frameworks, Design and Architectural Patterns for Robotics and Robot Sensing and Perception, course organizers claim it "provides the flexibility of being fully online while also giving students hands-on experience through the incorporation of robot kits into the curriculum."	http://www.brandeis.edu/now/2018/february/robotics-masters-gps.html
Bristol University	Bristol, U.K.	The MSc in Robotics program provides entrants with a "wide understanding of the practice and theory of advanced robotic systems, with wide-ranging applications from industry to research." Organizers said the course is unique by its ability to draw on the strength of two universities – the University of Bristol and the University of West of England, both partners in the Bristol Robotics Laboratory, described as a "world leading facility for multi-disciplinary robotics research, and the leading and largest academic centre for robotics research in the U.K."	http://www.bristol.ac.uk/engineering/interdisciplinary/robotics/
Carnegie Mellon University Robotics Institute	Pittsburgh, Pa.	Since its establishment in 1979, CMU has cemented its position as one of the leading robotics research centers in the world. In addition to a range of undergraduate options, the university offers postgraduate programs including Master of Science degrees in robotics, computer vision, robotics systems development, and a robotics Ph.D program. The school recently launched an undergraduate degree in artificial intelligence, which it says was established in recognition of the ongoing technical breakthroughs in the field, and rising demand for AI-based training by students and employers.	https://www.ri.cmu.edu/
ETH Zurich	Zurich, Switzerland	The popular Master of Science in Robotics, Systems and Control course is "open to students seeking an outstanding education at the interface between mechanical and electrical engineering and computer science."	http://www.master-robotics.ethz.ch/
Georgia Institute of Technology	Atlanta, Ga.	Since 2008, Georgia Tech has offered what it calls "the first and only interdisciplinary Ph.D program in robotics in the U.S." In addition to conducting original research to prepare a doctoral thesis, students must also complete 36 hours of coursework and concentrate on three out of five core robotics areas – mechanics, controls, perception, human-robot interaction, and artificial intelligence & autonomy.	http://phdrobotics.gatech.edu/

University/Institution	Country/Location	Brief description	Website
Massachusetts Institute of Technology (MIT)	Cambridge, Mass.	In addition to its popular Introduction to Robotics undergraduate course, MIT also boasts a vibrant Ph.D program at the computer Science and Artificial Intelligence Lab (CSAIL), with students focusing on a range of subjects, including Algorithms & Theory, Human-Computer Interaction, and Computational Biology and Robotics.	https://www.csail.mit.edu/
Technical University of Dortmund	Dortmund, Germany	Offers a much sought-after master's degree program in Automation & Robotics.	http://www.e-technik.tu-dortmund.de/cms1/de/Lehre_Studium/Studienangebot/Master_A_R/Master_A_R_en/index.html
University of Michigan	Ann Arbor, Mich.	The robotics program offers master's and Ph.D engineering degrees that apply knowledge and expertise from a range of technical fields to robotics applications. In doing so, the program focuses on three core disciplines viewed as "essential to robotics" – sensing, reasoning, and acting.	https://robotics.umich.edu/academic-program/
Stanford University	Stanford, Calif.	The Computer Science Department runs a sought-after master's degree in artificial intelligence that touches on a wide range of important principles and techniques, including knowledge representation and logical reasoning, robotics, and machine learning. The Stanford Robotics Lab also offers a range of relevant undergraduate courses, including Introduction to Robotics, Experimental Robotics, and Advanced Robotics.	https://cs.stanford.edu/groups/manips/
Worcester Polytechnic Institute (WPI)	Worcester, Mass.	Along with undergraduate offerings, WPI offers a master's degree in robotics engineering, which it describes as a "leading, first-of-its-kind graduate program in the nation, and an internationally lauded academic program."	https://www.wpi.edu/academics/study/robotics-engineering-ms

CASE STUDY #1: A DAY IN THE LIFE OF A ROBOTICS EXPERT

According to a recent analysis by Study.com, the fact that modern robots are used in such a variety of ways means that the day-to-day tasks carried out by experts working in the sector "vary greatly depending upon the function and application of robotics in his or her work."

For example, some robotics engineers work on the creation of cutting-edge prosthetic limbs, while others are focused on the design of automated manufacturing systems at food-packaging plants. Despite these differences, most robotics engineers assume responsibility for "designing, creating, testing and troubleshooting problems with their robots." This process involves extensive research in various mechanical and robotics technologies, as well as the use of several design software, electrical, and mechanical equipment.

Credit: Volkswagen

Teamwork is a big part of the day in the life of robotics expert at Volkswagen Group's IT Smart Production Lab.

An interesting example of the variety of daily tasks undertaken by a professional in the sector is Johannes Teiwes, a robotics expert at the Volkswagen Group IT Smart Production Lab, which works on applying smart and new technologies for the production of mass-customized vehicles, such as the Volkswagen Golf. Teiwes said his specific role at the lab is to research, develop, and implement functional modules and applications for lightweight robots used to "support human workers at repetitive and physically stressing tasks."

"Simply put, they have to make human work better and less stressful," Teiwes said.

Because innovation is a "team sport," Teiwes said his day begins with a daily stand-up meeting, where all the colleagues from his department briefly outline their tasks and challenges for the day, meaning that "everyone can benefit from the work of others and share their knowledge across the team."

Following this, Teiwes works on writing code for robotics applications, developing programs focusing on tasks ranging from real-time signal processing, for example, the detection of an object in a camera frame, to higher-level task descriptions for multiple robots.

"Numerous lightweight robots are already running 24/7 in production," he said. "From time to time, my task is to optimize their programs, extend their functionality and adapt them to the needs of the production on site."

Credit: Volkswagen

A robotics expert will write code, develop programs focusing on different tasks, and create new features.

The first step Teiwes took when starting out his career in robotics was to study Systems Engineering at the University of Bremen, specializing in control, kinematics and the low-level programming of embedded systems. Following this, he also gained three years of work experience in the Robotics Innovation Center at the German Research Center for Artificial Intelligence (DFKI), which he describes as the "world's largest and most renowned scientific institution specializing in artificial intelligence."

"Volkswagen acquired a stake in DFKI some years ago and is very actively cooperating," Teiwes said.

Looking ahead, Teiwes said the complexity of robotic systems and applications in the automotive sector will grow in the coming years and decades, with a key challenge for new entrants to the profession likely to be "how to master single modules of a complex system as well as having a global understanding of the final application."

"This will be mainly a task of writing software, which can be tested, composed, evaluated and deployed to physical systems," Teiwes said.

CASE STUDY #2: EMBRACING THE SWARM

Initiatives aimed at acquiring and enhancing robotics skills are not always confined to formal settings such as schools, universities and workplaces. A growing number of organizations run events that focus on developing and demonstrating technology smarts in a more relaxed community, or team-based environment.

Credit: NASA

Competitors at the NASA-backed Swarmathon create software code to operate autonomous vehicles known as "Swarmies" to operate as a collective swarm.

The NASA-backed Swarmathon, an annual robotics programming competition, aims to cultivate novel ideas and designs for technology "that could help astronauts find needed resources while exploring the Moon or Mars."

As part of the 2018 event, participants focused on creating software code to operate cutting-edge robots known as "Swarmies" – miniature autonomous vehicles equipped with an integrated sensor, webcam, GPS, and Wi-Fi antenna – that could be programmed to communicate and interact as a collective swarm.

Theresa Martinez, the MUREP STEM Engagement manager at the Kennedy Space Center's Education Projects and Youth Engagement Office, said in a statement that participants developed practical skills that could aid NASA's ongoing space-exploration goals.

"Swarmathon students gain experience with code integration, hardware testing, software engineering, project management and team collaboration critical to their future success in robotics and computer science," Martinez said. "Their efforts will further advance 'swarm robotics' technology for future NASA space exploration missions and we hope some of the students will return and help us in the future."

CASE STUDY #3 - LIFELONG LEARNERS AND CAREER SWITCHERS

In the recently published "Automation Readiness Index", produced by The Economist Intelligence Unit and ABB, the continuous transformation of the labor market of the future will call on individuals to cultivate a "high degree of adaptability" and commit to learning throughout their working lives.

Recognizing that technology often changes the way individuals work, sometimes fundamentally, the report singles out continuous education and "lifelong learning" as a crucial strategy. This provides people with an opportunity to "voluntarily undertake training throughout their careers in order to acquire new skills," the report stated.

It cited an interesting experiment currently underway in Singapore that aims to help citizens with this challenge. The country provides "citizen credits" that can be used to finance study throughout a citizen's lives. As part of the experiment, established in January 2016 as part of the government's SkillsFuture initiative, every citizen 25 or older can claim a credit of $500 Singapore dollars (about $361.27) to set up an "individual learning account" that can be used to finance courses at any of the 500 government-backed training providers.

A positive approach to continuous learning and adaptability is also useful for those contemplating switching careers to a job in robotics. One interesting recent initiative, known as Programming by Demonstration, seeks to equip

New initiatives offer lifelong opportunities for students and mid-career professionals to get involved in learning about robotics.

computer scientists and software engineers without engineering degrees with skills in robotics deployment - an industry expected to expand in tandem with the burgeoning robotics sector.

The program, created by Maya Cakmak, director of the Human-Centered Robotics Lab in the Computer Science and Engineering Department at the University of Washington, was created to address the issue of robot programming, which can be very difficult for small- and midsize businesses lacking the resources to employ a qualified roboticist. In basic terms, the approach enables users to physically demonstrate a task and equip a robot (or cobot) with the ability to work out the correct program to recreate the necessary movements.

Elsewhere, a team at Bluefield State College in West Virginia has pioneered a system that uses cobots to transition displaced miners into manufacturing jobs. As part of the program, two Sawyer collaborative robots from Rethink Robotics are used to expose students to robotics and its role in modern manufacturing systems.

LARGE LANDSCAPE, MANY OPPORTUNITIES

Whether you're a high school or graduate student, or a seasoned professional looking for mid-career change, the robotics sector is offering a wealth of opportunities to progress a career and provide personal growth. Advances in robotics technologies and capabilities are leading to a rapid surge in the demand for experts across several fields – from precision agriculture and autonomous vehicle development, to machine learning, AI and the Industrial Internet of Things.

This expansion draws from expertise from several backgrounds and disciplines, including computer science, neuroscience, mechanical engineering, electrical engineering, material science, physiology – even ethics and psychology. It is increasingly likely that the robotics experts of tomorrow will be called upon to adopt a truly agile and inter-disciplinary approach to their working lives, not only to navigate an increasingly complex and demanding career landscape, but to thrive and prosper in the future workplace.