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THE STATE OF ARTIFICIAL INTELLIGENCE IN ISRAEL

INNOVATION CENTRE DENMARK IN-DEPTH REPORT

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Abstract

This report portrays the developments in Israel within the field of artificial intelligence (AI). It shows that there is a concerted effort in Israel across academia, industry, government and society to further improve on an already advanced position globally.

Particular strengths of Israel in AI relate to an academic sector that is producing quality research, teaching an ever-increasing number of graduates with skills in AI as well as being highly in touch with industry through joint research centres and technology transfer.

In addition, a thriving start-up scene with close to 1'000 AI start-ups across various levels of maturity is attracting significant international attention. The presence of over 60 multinational corporations with dedicated AI research and development centres serves as a training ground for the workforce and ensures research and development that can be considered cutting edge on a global scale.

Lastly, the government has already invested billions of Kroner in a variety of AI related activities and is in the midst of preparing a national AI strategy with additional resources.

1. Analytical framework

1.1 Definition of Artificial intelligence

Since no common definition has been established among Danish, European and Israeli stakeholders on the subject of AI, this report follows the definition of the term artificial intelligence as defined by the European Commission's High Level Expert Group on Artificial Intelligence in December 2018¹:

"Artificial intelligence (AI) refers to systems designed by humans that, given a complex goal, act in the physical or digital world by perceiving their environment, interpreting the collected structured or unstructured data, reasoning on the knowledge derived from this data and deciding the best action(s) to take (according to pre-defined parameters) to achieve the given goal. AI systems can also be designed to learn to adapt their behaviour by analysing how the environment is affected by their previous actions.

As a scientific discipline, AI includes several approaches and techniques, such as machine learning (of which deep learning and reinforcement learning are specific examples), machine reasoning (which includes planning, scheduling, knowledge representation and reasoning, search, and optimization), and robotics (which includes control, perception, sensors and actuators, as well as the integration of all other techniques into cyber-physical systems)."

1.2 Methodology

The aim of this report was to provide an accurate picture of the state of affairs within the field of AI in Israel in 2018. To do so, desk research and select interviews have been conducted. For an accurate picture of AI activity in early stage venture building, the Israel Venture Capital Research Center was commissioned with contributing its data and findings. In order to compare AI venture activity across countries, international databases such as Crunchbase were used. In relation to information surrounding government policies and plans, the Innovation Centre conducted a series of qualitative interviews with the following parties: Council for Higher Education, Startup Nation Central and the Samuel Neaman Institute for National Policy Research. In addition, the field of AI is in its very nature cross disciplinary and its applications are to be found in a myriad of academic fields and industries. In practice this means that it is almost impossible to distinguish AI as an independent field from related fields of activity which are particularly prominent in Israel such as cyber, fintech, etc. A certain overlap with other fields could therefore not be prevented.

¹ Retrieved from https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=56341

2. Israel – A global AI powerhouse

In order to understand the various developments in AI in Israel, the next chapters seek to benchmark Israel with other leading AI ecosystems, paint a picture of the historical grounds on which the developments in AI have taken place and present an overview of the current state of affairs.

2.1 Comparing Israel with other leading countries in AI

The attempt to benchmark countries in relation to their skills and capabilities in AI is a daunting task and will never be able to paint a complete picture of reality. To illustrate the complexity of such a task the recently published AI Index² led by Stanford University compiled scientific, commercial, technical and other indicators in its 100 page report. While it attests that Europe is doing very well in terms of scientific publishing, the report refrains from detailed country rankings as many other reports do as well. Furthermore, most reports do not have reproducible methods³. Consultancy Oxford Insights asked which government is most ready for AI. Leading the ranking is the UK, followed by the US and Canada. Israel placed 14th, Denmark 21st.⁴

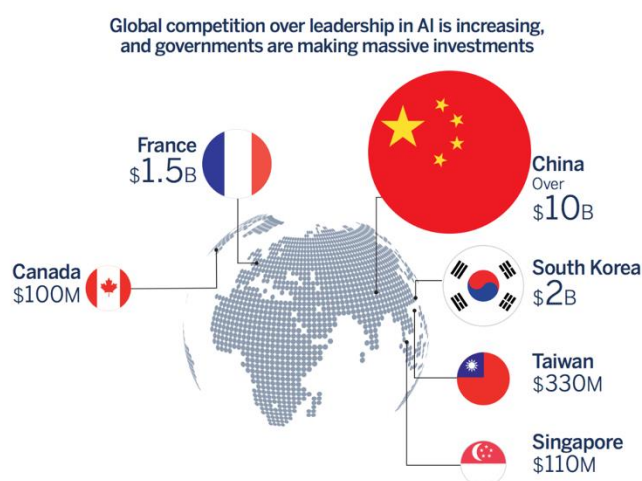


Exhibit 2: Select countries investments in national AI strategies⁵

What is common to all these reports is their mentioning that the outcome is very much dependent on countries' government actions. While neither Denmark nor Israel have announced national AI strategies, as can be seen from the various government investments

² 2nd edition retrieved from <http://cdn.aiindex.org/2018/AI%20Index%202018%20Annual%20Report.pdf>

³ Claimed by Dr. Stefan Heumann and Nicolas Zahn after reviewing 10+ meta reports, retrieved from page 20 at https://www.stiftung-nv.de/sites/default/files/benchmarking_ai_strategies.pdf

⁴ <https://www.oxfordinsights.com/government-ai-readiness-index/>

⁵ Retrieved from page 53 from <https://innovationisrael.org.il/en/sites/default/files/2019-01/Israel%20Innovation%20Authority%20-%202018-19%20Innovation%20Report.pdf>

in AI in the exhibit above, the global race for AI leadership has clearly begun.

2.2 Historical analysis of AI origins in Israel

Israel has long had a strategic focus on self-reliance in “critical infrastructure”. This critical infrastructure is very different from what other countries would consider “critical infrastructure” and includes the creation of its own defence industry, a nuclear program and a large sector of nationalized companies to serve the needs of its citizens as the state was under heavy boycotts internationally. It is against this backdrop that many of the capabilities that Israel is known for today were created.

In the case of artificial intelligence, Israel’s position as a global powerhouse in AI has strong roots in both the military as well as its academic institutions and the close cooperation between the two. On the academic side, Israel has had a long tradition in mathematics and physics with local universities and research institutions being early adopters of computers back in the 1950s and 60s. On the military side, in addition to the capabilities it had built up during the numerous wars subsequent to its independence it was the military’s need that drove early technology adoption in AI. “The big breakthrough came after the Yom Kippur War when Israeli intelligence needed to develop new technologies to deal with regional threats,” says Professor Naftali Tishby, from the Hebrew University’s Center for Brain Science and School of Computer Science and Engineering. It was up to the Israel Defense Forces 8200 intelligence unit and other less well-known units to develop new intelligence-gathering systems based on early speech recognition and deep learning technologies. Hundreds of young soldiers who served in the secret units in those years were responsible for leapfrogging Israel’s intelligence capabilities from primarily human to technology-based operations. Many then went on to form the backbone of the engineering and scientific talent at Israel’s defence industries at companies like Israel Aerospace Industries, Rafael Weapons Development Authority, Elbit and others.

2.3 Current state of affairs – The stakeholders making up the Israeli AI ecosystem

It is not least due to these historical developments that Israel today is recognized as a global leader in artificial intelligence technologies. Israel is home to a closely interrelated network of excellent research, technology talent, a burgeoning ecosystem of start-ups, venture capital funds, incubators and a supporting government actively engaged in the field of AI as shown in the exhibit. This unique mix is often credited to be the major force in the results achieved by Israel in areas of high technological specialization such as AI⁶. This section seeks to give an overview on some of the key facts, activities and developments, which will then be elaborated on within the following chapters.

⁶ Mentioned in annual report by Israel Innovation Authority available at <https://innovationisrael.org.il/en/report/innovation-report-2018> and by Samuel Neaman Institute of Policy Research in their report titled “Artificial Intelligence, Data Science, and Smart Robotics – First Report Summary” on page 12 from <https://www.neaman.org.il/EN/Artificial-Intelligence-Data-Science-and-Smart-Robotics-first-report>

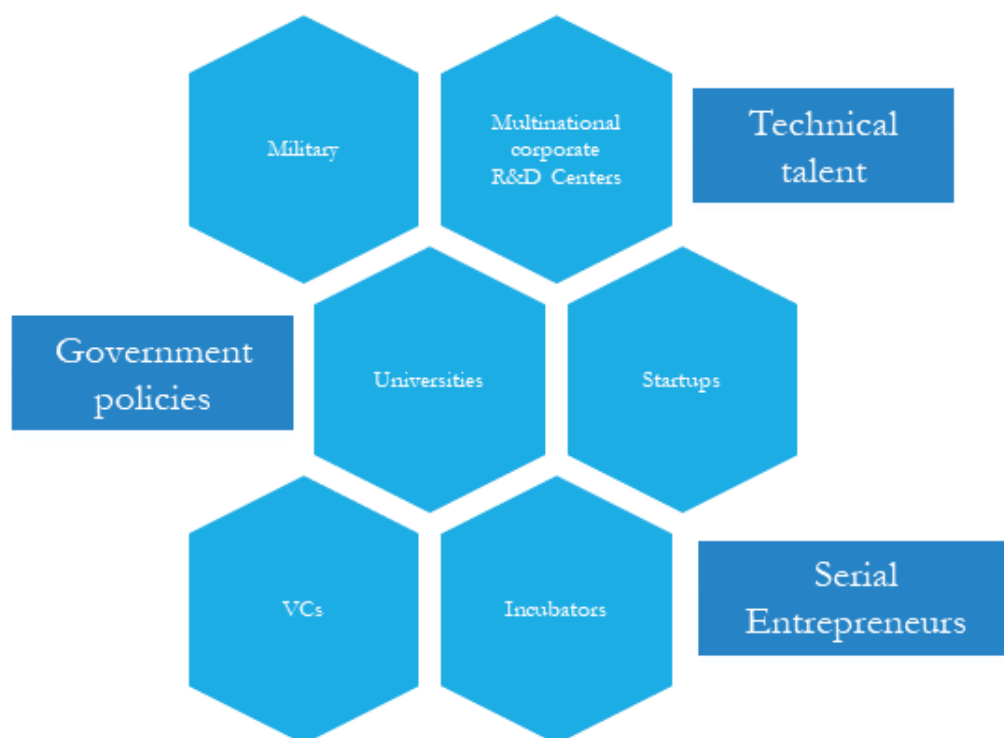


Exhibit 3: The Israeli AI ecosystem and its components

2.3.1 Government activity in AI

The Israeli government has made and continues to make substantial investments in AI related fields through a variety of initiatives. These broadly fall into the following three categories: opening up of data silos (many of which are government owned), education and supply of AI talent to academia and industry, changes in regulation and structures of government. In total, more than DKK 1.8 billion are being invested. In addition, the Israeli government is currently formulating a national strategy on AI. A council appointed by Prime Minister Netanyahu has commenced work in the summer of 2018. The strategy will take its inspiration from the highly successful cyber strategy adopted by Israel in 2011 that has transformed the country into a global leader in cyber technologies (it is estimated that Israeli companies account for approximately one third of global cyber security technology sales, competing with the United States for global leadership). In addition to the various public initiatives by the government, the Israeli military continues to play a crucial role in AI. It is heavily invested in the area in terms of work force and use of technology. It educates, trains and retains AI talent while being a major financier of AI infrastructure, applications and systems. As a result, many of the most innovative solutions in AI are developed in the army or by army graduates upon completion of their service.

2.3.2 AI workforce

Israel hosts one of the biggest communities of AI professionals in the world with over 4'000 dedicated AI professionals⁷ when compared to several ten thousand professionals estimated to be working in the field worldwide⁸. These work across multinationals, start-ups, government

⁷ Retrieved from <https://www.forbes.com/sites/gilpress/2018/09/24/the-thriving-ai-landscape-in-israel-and-what-it-means-for-global-ai-competition/#11d355ee30c5>

⁸ Estimate by the Samuel Neaman Institute retrieved from <https://www.neaman.org.il/EN/Artificial-Intelligence-Data-Science-and-Smart-Robotics-first-report.>

(particularly within the military), academia and sometimes even in academia and industry simultaneously (Israeli professors for example are allowed to work up to 20% outside of academia in parallel to their university work). Nevertheless, Israel is currently experiencing a severe shortage of AI talent, which has led to a sharp increase in wages, outsourcing of development work to other markets, increased competition and cooperation between academia and industry as well as other related market reactions. For a data scientist with five years of experience the average salary is DKK 49-58'000 per month, which is the highest among many other development positions with a similar level of experience⁹. In response, the Council for Higher Education, the national body responsible for higher education, has dedicated in excess of DKK 1.3 bio. in its multiyear plan from 2017-2022 to increase the number of students and faculty members in engineering and computer science studies¹⁰. This has resulted in computer science departments in Israel now being able to hire more faculty with a focus on AI and offer more courses in AI related technologies, such as computational learning, natural language processing, automation, robotics, and decision-making systems. The number of first year undergraduate students in high tech fields¹¹ has increased from approx. 6'000 per year in 2012 to 7'000 in 2016 and due to the additional investments is projected to reach 11'000 in 2022¹². On the level of master and PhD level graduations, there is a 150% increase between the level of 2007 and 2018 from 60 to 90 graduations per year¹³. Beyond formal university education, the government is taking steps to also help retrain professionals as Startup Nation Central notes¹⁴: "In addition, intensive boot camp-style career reorientation programs in data science are being designed for scientists from a variety of disciplines in exact sciences. The Innovation Authority recognizes the shortage of data scientists as well, and in the coding boot camps it opened in 2018, three out of seven supported programs provide training in data science or machine learning."

2.3.3 AI at Universities

In teaching, dozens of courses and tracks are being offered both at the bachelor and at the master's level. This is met with great interest from students with courses often being oversubscribed. Several universities already have dedicated AI initiatives and AI centres, several of whom are co-financed and co-created with industry or through philanthropic donations. Under a national initiative by the Council for Higher Education these centre activities will now be expanded while a national scientific AI umbrella organisation will be established. Within research, there are approximately 270 researchers dedicated to the field. Research areas that Israeli researchers are particularly known for include autonomous systems and smart robotics, computer vision, natural language processing, deep learning and multi-agent systems among others. Israeli research ranks #35 globally in the total number of AI publications. It has less leading researchers than other leading countries but the output per scholar is equally high. Within the top 5 leading conferences, Israeli researchers published more than any other comparable country except Singapore. Israeli researchers also received at least 26 grants by the European Research council for research in the field of AI. Only 5 EU members and one associated state did better. In addition to their research activities, Israeli universities are

⁹ Retrieved from page 40 on <https://innovationisrael.org.il/en/report/innovation-report-2018>

¹⁰ Retrieved from <https://che.org.il/en/increasing-the-number-of-faculty-members-and-students-with-a-focus-on-the-engineering-and-computer-science-fields-needed-in-the-israeli-job-market/>

¹¹ Defined as the fields of Computer Science, Software Engineering, Computer Engineering, Electrical Engineering, Information Systems Engineering, Data Science

¹² Taken from presentation given by Yaffa Zilbershats to Copenhagen University Science delegation on January 21, 2019.

¹³ Data based on Israel Union List analyzed by the Samuel Neaman Institute and retrieved from <https://www.neaman.org.il/EN/Artificial-Intelligence-Data-Science-and-Smart-Robotics-first-report.>

¹⁴ Page 40 on <https://innovationisrael.org.il/en/sites/default/files/2019-01/Israel%20Innovation%20Authority%20-%202018-19%20Innovation%20Report.pdf>

particularly active in technology transfer within AI. A recent success was achieved by university spin off Mobileye, which was co-founded by a professor at Hebrew University in the field of computer vision. Intel acquired the company, which had been founded in 1999, in 2017 for DKK 100 billion, the largest acquisition of an AI company globally to date. As a result, Intel moved all of its autonomous driving development operations globally to Israel.

2.3.4 Kinds of AI being developed in Israel

It is fair to say that what is developed in the commercial AI sector reflects the developments in the military and academia. Within academia, 'Input arrangements for transferring data' is considered the leading patent technology classification (in terms of the number of distinct applications). This refers to input processing that can be manipulated by the computer. Multinational corporates operating R&D centers also primarily patent this technology with writing recognition technology being the second most patented technology.

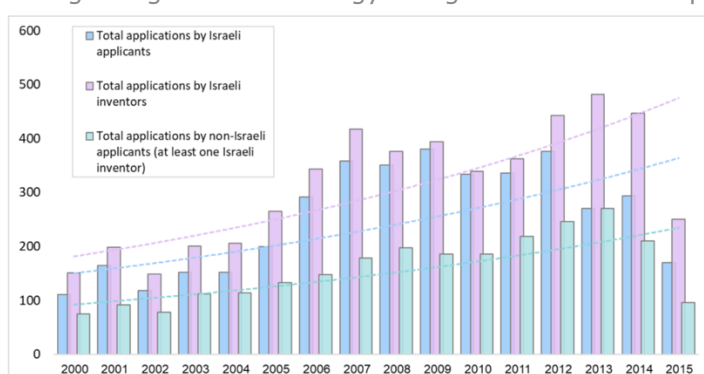


Exhibit 4: Israeli Patent applications in AI¹⁵

Overall, the Israeli AI sector initially focused on computer vision and has since become extremely active in other segments including natural language processing, analytics and robotics. There is significant activity in AI core technologies drawing on Israel's expertise in developing hardware, architecture and algorithms. Unique to Israeli AI is the significant overlap and resulting cross-fertilization with other technologies that Israel has historically been strong in such as cybersecurity, network applications, agricultural technologies and others. Key commercial end markets currently targeted by Israeli AI are Automotive, Commerce, Healthcare, Fintech & Insurance, Cybersecurity and Marketing/Adtech. Ultimately, these developments result in a wide variety of highly innovative commercial use cases as shown in the exhibit with companies producing robot insurance and autonomous driving solutions

¹⁵ Graph on page 8 retrieved on January 7, 2019 from <https://www.neaman.org.il/EN/Artificial-Intelligence-Data-Science-and-Smart-Robotics-first-report>

alongside each other.

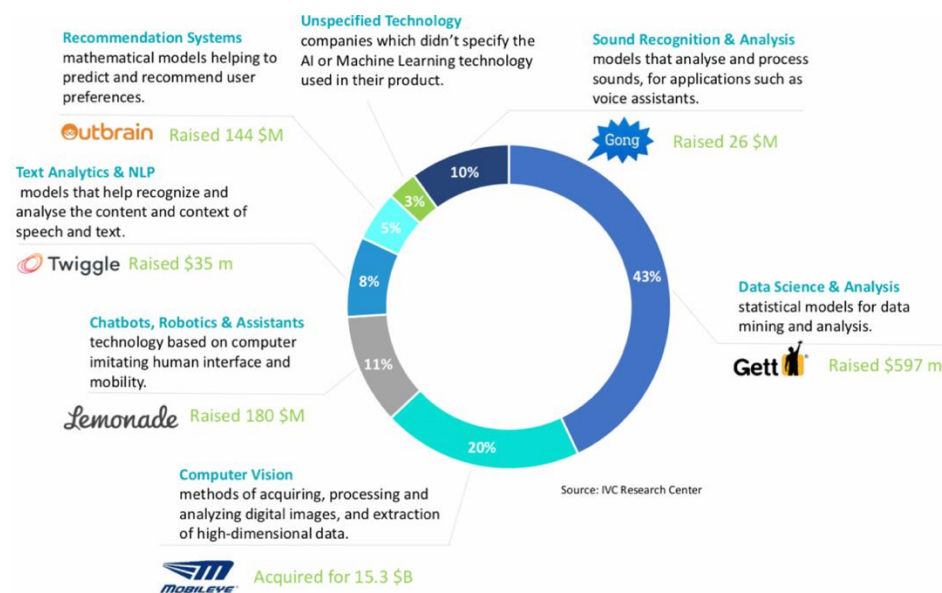


Exhibit 5: Kinds of commercial AI being developed by companies in Israel¹⁶

A certain amount of trend based commercial development can be noted as IVC research center states¹⁷: "Until 2013, computer vision was the main AI technology being developed by Israeli companies. Since 2012 new technology trends like big data and data science became more dominant. The decline in the number of new companies in 2017 occurred mainly in those developing algorithms for computer vision, chatbots and robotics. Data Science & Analytics has been the major driver of growth in the Israeli AI cluster throughout the last decade. While there is significant growth in all AI sectors, in the last 4 years we are seeing an even higher growth of Data Science and Chatbots/Robotics/Assistants companies."

It is interesting to contrast these external assessments with the Israeli point of view. Based on 60 in-depth interviews with experts from the field of academia, industry, government and military in Israel these claim that Israeli AI possesses a relative competitive advantage in medicine and cyber as well as transportation and game theory while no relative advantage could be assessed in smart robotics¹⁸.

It is important to note that the vast majority of these solutions are being exported without being applied to the local market unlike many European technologies. This has created somewhat of an imbalance in Israel whereby for example, Israeli companies are developing AI software for driverless cars but Israeli consumers do not immediately benefit from these. The Israel Innovation Authority, has recognized this issue and is looking to incentivize companies to also offer their solutions to local companies and consumers so that they may benefit from the advancements in technology more immediately.

2.3.5 Start-up & venture capital activity

According to a recent report by Roland Berger & European Venture Capital Firm Asgaard, Israel is home to the third largest AI start-up ecosystem globally, trailing behind only the United States and China. When compared to other technology verticals in Israel, the AI ecosystem has

¹⁶ Graph provided by IVC Research Center.

¹⁷ https://www.ivc-online.com/Portals/0/RC/POSTS/Israeli%20AI%20Ecosystem%20-%20FINAL.pdf?timestamp=1543760654510&utm_source=Linkedin

¹⁸ Page 12 retrieved from <https://www.neaman.org.il/EN/Artificial-Intelligence-Data-Science-and-Smart-Robotics-first-report>

outgrown other technologies in terms of funding and number of companies by a large margin as can be seen from the exhibit from the Israel Innovation Authority.

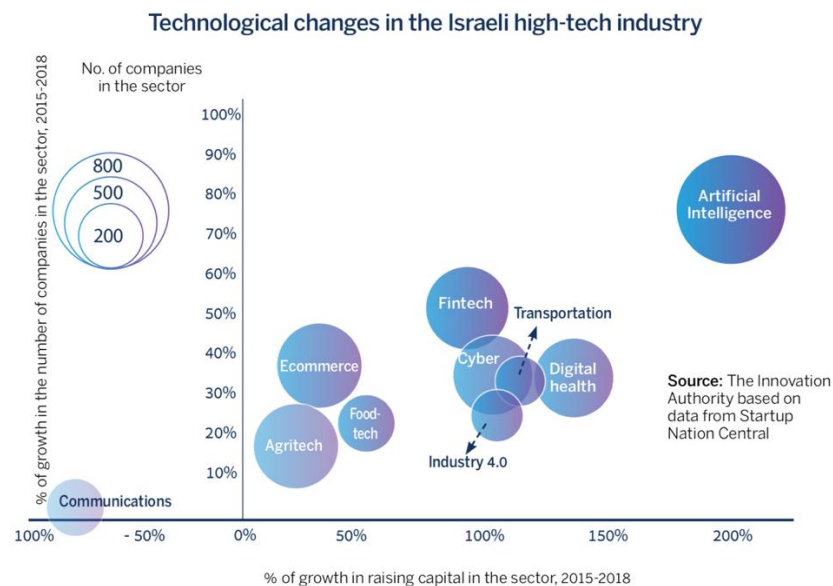


Exhibit 6: Growth of artificial intelligence category in Israel in terms of number of start-ups and capital raised relative to other technology areas¹⁹

The ecosystem is made up of approximately 1'000 AI start-ups representing around 15% of all Israeli start-ups. For comparison, Denmark has approximately 50 mostly early stage start-ups in AI²⁰. In terms of company stage, 50% of these companies are early stage, an additional 44% have significant revenues but do not yet exceed DKK 65 million in annual sales and 6% of companies have passed this threshold. For early stage companies a myriad of incubators, accelerators and mentors exist. Collectively 216 AI start-ups attracted DKK 10.5 billion in funding in 2018. This represents strong growth momentum compared to approximately DKK 2.3 billion invested in 100 deals in 2013. Deal sizes are increasing and so are the sizes of the investments. This is related to a coming of age of Israeli AI start-ups whereby there is an ever increasing number of so-called "scale ups"²¹ which employ dozens to hundreds of employees and have raised dozens to hundreds of millions in funding. All of these scale ups are privately held and none have announced plans for initial public offerings despite them being considered so called ponies (valuations in excess of USD 500 million) or unicorns (valuations in excess of USD 1 billion). In parallel to the start-up growth, there has also been strong growth in dedicated venture and private equity capital allocated to the AI category. The most active funds have made over 10 AI investments each in the last two years alone. Financial performance in terms of exits has also been strong in many cases with the above-mentioned Mobileye and others setting new records. The capital for these funding rounds comes mostly from foreign sources with the United States, China and Europe being the biggest investors in Israeli technology companies.

¹⁹ Data retrieved from page 42 of <https://innovationisrael.org.il/en/report/innovation-report-2018>

²⁰ Data collected by searching the Danske Hub website (thehub.dk) for the terms artificial intelligence, machine learning and data science in addition to reviewing the database of Nordic.AI (<http://nordic.ai/database/>).

²¹ "All enterprises with average annualised growth greater than 20% per annum, over a three year period should be considered as high-growth enterprises. Growth can be measured by the number of employees or by turnover" from <http://www.oecd.org/sdd/business-stats/eurostat-oecdmanualonbusinessdemographystatistics.htm>

2.3.6 Multinationals active in AI

In addition to vibrant activity by academia, government and startups, over 350 multinational corporations operate research & development centres in Israel. As of today, an ever-growing number of these corporates are also active in the field of AI in Israel representing a variety of industry verticals²². Companies like Apple, Amazon, Facebook, Google, as well as industrial companies such as Intel, IBM, Nvidia, Ford, GM all employ dozens and often hundreds of AI professionals in Israel in addition to their other workforce. Rather than operating in a silo, most of these corporates operate significant joint ventures with universities or interact in meaningful ways with the start-up ecosystem through dedicated incubators, investments or other means.

2.3.7 Israeli industry and AI

Besides its defence industry, Israeli industry is not known to be particularly innovative. The Innovation Authority has referred to these developments as a two-state economy whereby the high-tech sector is quite separated from the industrial part. In order to increase innovation with the industrial sector, the Israel Innovation Authority finances a number of programs. The government has also made this a national priority. Specifically, as it relates to AI there are a small number of industrial companies engaged at this point²³.

2.4 Summary & focus areas

The previous chapter has given a first overview of some of the key facts, developments and activities at play within the AI ecosystem of Israel - the table below summarizes some of these.

Key facts on AI in Israel

Number of startups	1'000
Amount of venture capital invested in AI companies	DKK 10.5 billion in 2018
Number of corporates with AI R&D	>15
Number of researchers	270
Number of patents	Approx. 500 per year
Amount dedicated by government to AI initiatives	Several billion DKK
Number of universities with dedicated AI activities	8 out of 8
Primary commercial end markets	Automotive, Commerce, Healthcare, Fintech & Insurance, Cybersecurity and Marketing/Adtech.

Exhibit 7: Summary of key facts on AI in Israel as mentioned in previous chapter

Now that a basic understanding has been established, the following chapters seek to create a more detailed understanding within the areas of special interest to the stakeholders of this report. The areas where in-depth research has been conducted are:

1. Focus area I: AI talent in Israel
2. Focus area II: Government involvement in AI
3. Focus area III: AI at Israeli universities & academic colleges
4. Focus area IV: AI start-ups in Israel
5. Focus area V: Multinational Corporates active in AI in Israel

²² Data retrieved on January 16 from <https://startubhub.ai/ai-talent-pool-in-israel-from-multinational-corporations/>

²³ For example, food & beverage producer Strauss, the national electric company, pharmaceutical company Teva etc.

3. AI talent in Israel: industry needs and stakeholder positions

Not unlike Denmark, Israel is facing significant challenges in training and retraining its workforce within high tech generally and within AI specifically. For AI the biggest challenge is the shortage of talent. “The hiring of hundreds of AI engineers by Amazon and other global giants has exacerbated the manpower shortage and driven up costs,” says Yori Nelken, general partner at Cognitiv, an early stage AI fund. He adds that once start-up companies reach the level of 7 to 8 engineers, they are forced to outsource part of their development, usually outside of Israel. Startup Nation Central seconds these findings to some degree and reports that worldwide demand for data scientists grew by 650% in 2012-2017 and that salaries are continuously increasing, a trend also evident in Israel. Terminated employees have declined and voluntary departures are increasing – pointing to a high demand for skilled AI human resources²⁴.

To be more specific in addressing the talent shortage within AI, the Israel Innovation Authority has published a way to think about the training of such AI talent whereby these groups are addressed individually. The exhibit below shows four groups of talent separated by their varying degrees of competence in the field of AI.

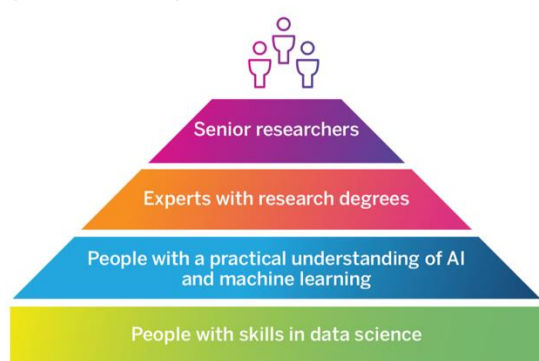


Exhibit 8: Target Israeli human capital pyramid required for lead in the field of AI²⁵

At the top of the pyramid are the senior researchers which are defined as those who specialize in algorithms and are needed for research and teaching in universities as well as in the professional sector. They are to be considered the most sought-after talent group, requiring an increase in the supply as well as attractive incentive structures in order to also remain in academia given the increased competition. The second group is made up of AI workers with

²⁴ https://innovationisrael.org.il/en/sites/default/files/SNC_2018_Human_Capital_Report_Final.pdf

²⁵ Data retrieved on January 24 from page 57 of <https://innovationisrael.org.il/en/report/innovation-report-2018>

research degrees connecting the worlds of academia and industry. A third group is made up of workers with a practical understanding and work experience in AI and a fourth group with skills in data science. Rather than being complacent about these challenges various players have taken it upon themselves to work towards closing this workforce gap.

3.1 Government guidelines & response to increased demand in AI workforce

As can be seen from the exhibit below, various initiatives by the government have been established to combat the lack of competent workforce. In particular, Israel has dedicated significant resources to improving the results of students in STEM related fields at the level of secondary education, increased its support regarding the entrance of Arab and ultra-orthodox students at the tertiary level as well as providing funding to private organizations offering extra-academic coding boot camps. Lastly, Israel has eased immigration significantly to attract foreign high-tech professionals (both Israelis living abroad as well as foreigners) to the local workforce.



Exhibit 9: Government response to talent shortage in high tech workforce

3.2 University response to increased demand in AI workers

The universities are experiencing increased demand and respond accordingly. The Technion experiences that 50% of applicants for graduate degrees in computer science want to focus on AI technologies. At Ben Gurion University the number of students seeking to specialize in AI technologies has also jumped in recent years. Approximately 50 engineers with wide knowledge of AI technologies graduate from the university each year, with a hundred more who have some knowledge of these technologies. Last year, the Technion opened a new study area focused on data science for undergraduate and graduate degrees. The universities have also seen a jump in students signing up to the computer vision course, from 50 to 250 and a new course on data mining has 300 students per semester. In response to this increased demand, the universities already offer a myriad of courses. An analysis of all AI related courses at universities shows that courses already exist within the following 7 areas: "

- Information Systems / Data Science;
- Artificial Intelligence / Machine Learning / Intelligent Systems / Distributed Systems;
- Bio-Informatics / Cognition / Psychology with emphasis on information studies;

- Combined track of intelligence /Learning Systems and Information Science;
- Robotics / Autonomous Systems
- General tracks without specialization - a variety of courses
- General tracks - individual courses²⁶

3.3 Industry response

In addition to the activities of government and academia the industry and in particular the start-up industry has taken an active stance as well. They have lobbied the government significantly to create visas for high tech professionals as well as offering significant benefits for professionals taking the leap to move to Israel. Together these start-ups are to a large degree looking for professionals in AI and have pledged to offer:

- Up to DKK 130'000 relocation bonus
- Yearly roundtrip flight home
- Apartment hunting assistance
- Housing for first six weeks in Tel Aviv
- School & community matching assistance
- Paid cell phone
- Hebrew tutor
- Help from an accountant who understands US/Israel tax law²⁷

²⁶ Page 23 retrieved from https://www.neaman.org.il/EN/Files/Artificial-Intelligence-Data-Science-and-Smart-Robotics_20181204151639.784.pdf

²⁷ Retrieved from <https://www.betelaviv.com/>

4. Government involvement in AI

Various arms of the government have been vocal in recent months about the need to “win” the global technology race in AI. The Israel Innovation Authority states in its most recent annual report: “Past successes could indicate that the Israeli ecosystem of innovation will certainly lead the AI wave of innovation, even without special intervention by policy makers. We believe that taking this passive stance runs the risk of Israeli technology losing its lead.” and further: “Accordingly, we are calling for the consolidation of all sectors – government, academia, and industry – to establish a vision and a strategy on AI for the Israeli economy.” As a result, several actions have and are being taken to ensure Israel technological leadership within the field of AI which will be presented in this chapter.

4.1 A national AI strategy under swift development

The national AI strategy is being developed under the same leadership as the cyber strategy and is led by Prof. Isaac Ben-Israel and Prof. Eviatar Matania. On the interconnectedness of the strategy to achieve results in the Israeli context, Prof. Ben-Israel states: “We want to achieve the same thing on a national scale that we did eight years ago. We submitted the report to Netanyahu in May 2011, a year after we began. We managed to trigger a national project of industry combined with higher education, the educational system, the government, and the Ministry of Defense. Without this combination, nothing would have moved here. In order to succeed, we have to guarantee synergy between all of the agencies, so that each one will both contribute to the others and get something in return.”²⁸

4.2 Government ministries and authorities’ actions in AI

One major initiative of this kind is the central government initiative of Digital Israel with a budget of DKK 1.6 billion. Its aim is to leverage the potential of the digital revolution in order to drive long-term economic growth by making Israel a global leader in the digital domain. A particular cornerstone of the project is to digitize the government and make its data available, making it more citizen and business friendly while opening up new engines of growth for industry. The initiative is the central point of departure for several sub-initiatives such as “Digital Health” with the Ministry of Health, “Digital Education” with the Ministry of Education, “Digital Economy” with the Ministry of Economy and “Digital Welfare” with the Ministry of Social Affairs and Social Services. As an example project of the initiative, anonymized health data is made available to industry and academia in order for artificial intelligence solutions to improve the health of the entire population²⁹ as well as build innovation solutions that can be exported. Given the relevance of AI in the field of autonomous driving, the Ministry of Transport and Road Safety has launched the “National Plan for Smart Mobility” running from 2017-2021 funded with DKK 362 million. Its goal is to incentivize R&D and entrepreneurship in the area and to

²⁸ <https://en.globes.co.il/en/article-well-make-israel-one-of-the-worlds-five-leading-countries-in-ai-1001249707>

²⁹ Retrieved from pages 19-20 of <https://www.neaman.org.il/EN/Artificial-Intelligence-Data-Science-and-Smart-Robotics-first-report>

open up the national transportation system to innovation actors. With a budget of several ten million Danish Kroner, the Ministry of Economy is running the established national strategic plan for advanced industrial production. This includes the use of information technologies such as AI. Included in the program are grants for small and medium-sized firms, the founding of an Institute for Advanced Production as well as educational activities. Already in 2018, five consortiums engaged in AI related fields competed for the funds.

In the Ministry of Science and Technology a research grants program encourages applied scientific and engineering research as well as international cooperation. The Government ICT Authority is working to integrate technologies such as AI into government ministries and services. There are additional programs within the Ministry of Education, the Ministry of Defense as well as the Ministry of Welfare.

4.3 Financing of higher education specialization in AI

The Council for Higher Education under the Israeli Ministry of Education, which is responsible for the budgets of higher education institutions in Israel, has defined AI as one of five flagship projects in their five-year plan. The approved four-year AI strategy aims to enhance research excellence in this area and involves the establishment of cross-disciplinary AI centres at all Israeli universities. Another aim is to enhance university collaboration with the major international R&D AI research centres present in Israel (such as Intel, Microsoft and IBM). Specifically, it contains the following six components:

Activity	Available Budget
Establish AI centres at all Israeli universities.	DKK 218 mio. Approx. 55% will be automatically awarded to qualifying centres, the other 45% will be awarded on a competitive basis.
Establish a national initiative to coordinate research and international efforts.	DKK 7 mio.
Program for PhD and Postdoc scholarships in academia.	DKK 18 mio.
Program to fund research together with Israel Defense Forces & security apparatus & Israel Science Foundation (funded 50% by Israel Defense Forces & security apparatus)	DKK 36 mio.
Program to fund research in public sector (funded 50% by Digital Israel Initiative)	DKK 29 mio.
Support to fund teaching & infrastructure in cloud computing (funded 50% by Digital Israel Initiative)	DKK 7 mio.
Total	DKK 315 mio.

5. AI at Israeli universities & academic colleges

Research at Israel's leading academic institutions in the field of AI is renown to be of high quality. Furthermore, Israel's strong academic foundation in AI has served as an important factor in the establishment of R&D sites of multinational companies as well as for hundreds of start-ups in the AI field and is likely to continue to play a critical role in the years to come.

The chapter hence gives an overview of the following fields of interest:

- Israel's scientific output in AI,
- human capacities in the field and its spread across universities,
- research interests within AI,
- AI activity and centres at Israeli universities,
- technology transfer activity of AI.

5.1 Scientific output

Commissioned by the National Council for Research and Development at the Ministry of Science and Technology, Israel has recently published a country comparison of its scholarly output in AI, revealing the following key performance metrics³⁰:

- Israel is ranked #34 in total publications (Denmark #35).
- Israel is ranked #18 in publications per million population (Denmark #6).
- Israel's number of publications compared with comparable countries (including Denmark) increased by 63% in the period of 2008-2017, (Denmark approximately on par).
- Israel's number of internationally coauthored publications compared with comparable countries (including Denmark) increased by 50% in the period of 2008-2017 (Denmark increased above average on relative level but below Israel on absolute level).
- Israel's demonstrated a moderate increase in the number of publications and normalized average citations in Israel and in 'comparable countries' in the period of 2003-2017 (Numbers for Denmark not immediately available).
- In the years from 2013-2017, Israel ranks 9 globally in terms of scholarly output in 5 leading conferences³¹. Except for Singapore, it produced more than any other

³⁰ Pages 3-8 retrieved on January 7, 2019 from <https://www.neaman.org.il/EN/Artificial-Intelligence-Data-Science-and-Smart-Robotics-first-report>

³¹ AAAI Conference on Artificial Intelligence, Computer Vision and Pattern Recognition, International Conference on Machine Learning, International Joint Conferences on Artificial Intelligence, Neural Information Processing Systems

'comparable country' (Numbers for Denmark not immediately available).

- Israeli researchers have received 483 European Research Council grants whereby at least 26 were related to AI.

5.1.1 Human capacity & research interests within Israeli AI research

On human capacity within research, the Samuel Neaman institute states: "A total of 270 researchers in the fields of Artificial Intelligence, Data Science and Smart Robotics, about 230 in universities and about 40 in colleges, were found in the mapping conducted by the research team. The most prominent universities in number of researchers are the Technion and Ben Gurion University (about 50% in all university researchers are from these two institutions). The most prominent colleges in number of researchers are the Interdisciplinary Center Herzliya, the Holon Institute of Technology, and the Sami Shamoon College of Engineering University (about 50% of all colleges researchers are from these three institutions)."³²

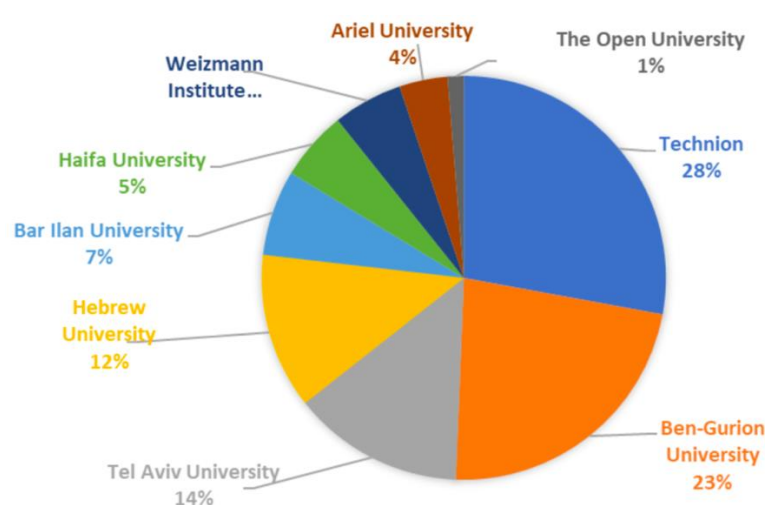


Exhibit 10: AI researchers by academic institute³³

In terms of faculties, the researchers mostly stem from the departments of computer science, electrical engineering and industrial engineering alongside less researchers in the faculties of aeronautical and aerospace engineering as well as civil engineering. The research interests mostly evolve around machine learning, artificial intelligence and autonomous systems and

³² Page 20 retrieved from https://www.neaman.org.il/EN/Files/Summary-ENG-Artificial-Intelligence-Data-Science-and-Smart-Robotics_20190103155714.257.pdf

³³ Page 21 retrieved from https://www.neaman.org.il/EN/Files/Artificial-Intelligence-Data-Science-and-Smart-Robotics_20181204151639.784.pdf

smart robotics as can be seen in the graph below.

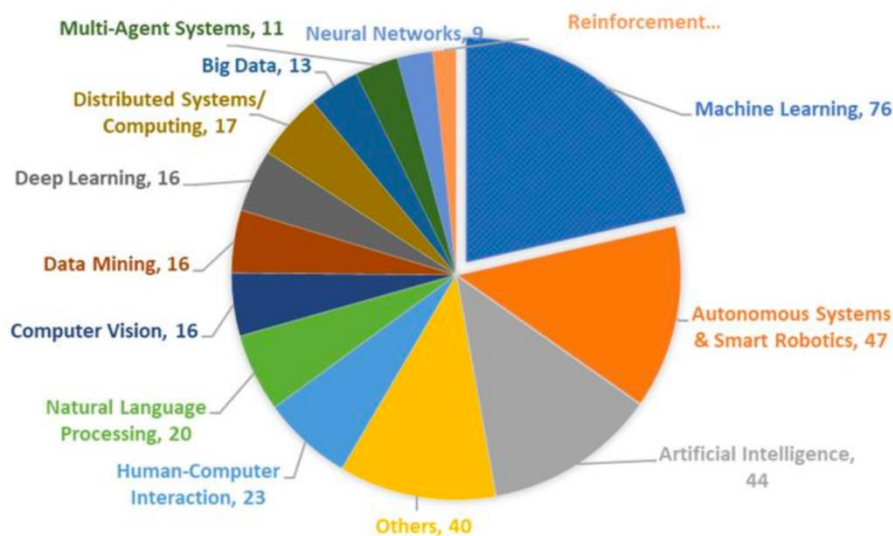


Exhibit 11: Research interests of Israeli researchers in AI related fields

5.2 An excerpt of AI Research centres and their individual focus areas

The following chapter seeks to describe the specific academic centres focusing on artificial intelligence. While it would be beyond the abilities of this report to address all centres in detail, a selection has been made that shows some of the excellence and research interests present in Israeli academic institutions. Excerpt of leading centres at Israeli Universities, some of which are described in more detail below:

- Hebrew University (Jerusalem): The Center of Knowledge in Machine Learning and Artificial Intelligence³⁴.
- Technion - Israel Institute of Technology (Haifa): Center for Intelligent Systems³⁵
- Tel Aviv University (Tel Aviv): Blavatnik School of Computer Science is heading the Yandex Initiative for Machine Learning³⁶.
- AI at Technion & Hebrew University in collaboration with Intel: Intel Collaborative Research Institute for Computational Intelligence³⁷.
- Bar-Ilan University: Natural Language Processing Lab and Multi Agent Artificial Intelligence group³⁸
- Ben Gurion University: The Department of Computer Science with a special emphasis on the intersection of cyber and artificial intelligence³⁹
- Weizmann institute: Weizmann Artificial Intelligence Center⁴⁰, DKK 660 million Initiative

5.2.1 AI at Technion

The center conducts theoretical and applied research in robotics and control, computer vision, image processing and learning. To encourage interdisciplinary interaction, and to promote

³⁴ <http://mlai.cs.huji.ac.il/>

³⁵ <http://cis.cs.technion.ac.il/>

³⁶ https://english.tau.ac.il/vision/yandex_initiative

³⁷ <https://elsc.huji.ac.il/content/intel-labs-launches-intel-collaborative-research-institute-computational-intelligence-israel>

³⁸ <https://cs.biu.ac.il/en/node/3477> and <https://cs.biu.ac.il/en/node/762>

³⁹ http://in.bgu.ac.il/en/natural_science/cs/Pages/Research/Research-AreasFromDB_AI.aspx

⁴⁰ <https://www.weizmann.ac.il/math/waic/home>

collaboration with local hi-tech industries. The Center for Intelligent Systems is a part of Departments of Computer Science and Electrical Engineering at the Technion, established in 1989. Currently, the Center for Intelligent Systems functions chiefly through the Intelligent Systems Laboratory in the Computer Science Department. Four senior faculty, and approximately 60 students are engaged in research in the Laboratory at all levels. Research projects include advanced undergraduate term and year projects, M.Sc. and Ph.D. theses, as well as advanced research and development cooperative efforts with commercial and industrial organizations. The scope of activities in the laboratory became more focused in the recent years covers research in areas such as computer vision, learning and autonomous systems. Special attention is given to multi agent robotics, biologically inspired vision and to medical applications.

5.2.2 AI at Technion & Hebrew University in collaboration with Intel

Launched in 2012, the Intel Collaborative Research Institute for Computational Intelligence (ICRI-CI), a collaboration by Intel with the Technion-Israel Institute of Technology and the Hebrew University of Jerusalem explores technologies that mimic the human brain's mode of action. Intel announced that it is establishing the Intel Collaborative Research Institute for Computational Intelligence to research future interaction between humans and technology. Founded with an investment of US\$15 million over five years, the Institute brings together researchers from the Technion in Haifa and the Hebrew University of Jerusalem. The Institute's staff totals approximately 40 researchers from the participating universities, a similar number of advanced degree students, and several Intel employees. The Institute focuses on machine learning, brain-inspired computation and advanced computer architectures, in the hope that these breakthrough technologies will enable future applications, such as programs that "get to know" the user and help him or her in various ways in real time. The Institute is headed by Prof. Naftali Tishby from the Hebrew University, Prof. Uri Weiser from the Technion, and Eng. Ronny Ronen from Intel. As a potential follow up, Intel and Technion in 2018 jointly launched the Center for Artificial Intelligence, further deepening the relationship between the two institutions.⁴¹

5.2.3 AI at Hebrew University

Getting computers to work together, cooperate, share resources, and avoid conflict form the School of Computer Science and Engineering's Artificial Intelligence Group's major areas of focus. Among the first in the field of artificial intelligence to apply principles from game theory to model protocols for computer agent cooperation, the Group helped establish a formal framework governing the high-level behaviour of interacting heterogeneous computer systems. Intelligent agents are computer programs that act as surrogates for users. Instead of a requiring a human to carry out time-consuming activities, an agent can do it automatically. The Group's current research revolves around building intelligent agents that can work together, applying economic theory, voting theory, and game theory to establish appropriate foundations for agent interaction. These agents might be cooperative and looking for ways to help one another, or they might be competitive and need to resolve conflicts that arise between them. In addition to world leading research, several companies in the AI field have been spun

⁴¹ <https://www.technion.ac.il/en/2018/10/the-technion-and-intel-to-inaugurate-joint-center-for-artificial-intelligence/>

out of the university in recent years, among them Mobileye, OrCam and Briefview.

5.2.4 AI at Tel Aviv University

Tel Aviv University (TAU) can be considered prolific in its activities around AI. At the university, there are initiatives in the fields of face recognition, systems intelligence and running multidisciplinary AI and machine learning research. Besides its own research and teaching activities, it is very active in fostering collaborations with academia and industry within the field of AI. In one example, TAU recently signed a cooperation agreement for joint research in “Smart Cities and Digital Living” with Stanford University, which draws heavily on big data and machine learning. The five-year grant, funded by the Koret Foundation of San Francisco, is bringing together leading scholars and scientists from TAU with their counterparts at Stanford to advance multidisciplinary, basic and applied research in data science that enhances the quality of life, safety and efficiency of cities, while supporting communications across people and organizations. In another example, in 2018 TAU partnered with Yandex, a Russian multinational technology company operating Russia’s largest search engine, to launch the Yandex Machine Learning Initiative. The initiative will run through TAU’s Blavatnik School of Computer Science as part of the Bachelors of Science program in computer science. The partnership will expand machine learning education at TAU through the launch of courses that will focus on machine learning, deep learning, natural language processing, computer vision, and robotics as well as a lecture series that will bring experts from around the world to lecture on machine learning and collaborate with TAU faculty. The initiative will also support the recruitment of new faculty and the acquisition of new equipment for research. Yandex Fellowships will provide scholarships opportunities to students at Master’s, Doctoral, and Post-doctoral levels. Tel Aviv University will be the sixth branch for the Yandex School of Data Analysis (YSDA.) YSDA will offer a one-year career advancement program in machine learning in fall 2018. While the partnership with Yandex is substantial and evidence of the growing interrelation between academia and business, the intellectual property generated in the various initiatives will remain with TAU.

5.3 Israeli Success Stories in technology transfer within the AI field

Today Israeli technology transfer companies generate a total of over NIS 1 Billion in royalties each year. While there are many examples of successful technology transfer in the AI field, this report aims to highlight three success stories, which shed a light on the breadth and depth of AI research commercialization efforts in Israel.

Mobileye Vision Technologies, provides warnings for preventing collisions on the road. The company was founded in 1999 on a technology developed by Professor Amnon Shashua of the Hebrew University and was commercialized by Yissum, the university’s technology transfer company. Mobileye, which has existed as a subsidiary of the Hebrew University since its founding, later developed a number of proprietary algorithms on which the company’s driver assistant technology is now based. In July 2013, Mobileye raised USD 400 million in a deal that valued the company at USD 1.5 billion⁴². It subsequently went public on NASDAQ with a market capitalization of ultimately USD 8 billion. In 2017, the company was bought by Intel for USD 15 billion – the biggest exit in Israel’s history.

Zebra Medical Vision is building a medical imaging insight platform using immense clinical data

⁴²

<http://online.wsj.com/news/articles/SB10001424127887323823004578592001583265658?cb=logged0.8389041114132851>

sets and computational resources. Zebra combines its vast imaging database with deep-learning techniques to build algorithms that will automatically detect and diagnose medical conditions, helping hundreds of millions of people receive fast, accurate imaging diagnoses. The company was founded as a spin-off of the technology transfer arm of Clalit Health Services, the healthcare provider for over 4 million Israelis. To date, it has raised over USD 50 million, employs approximately 50 staff and recently became one of the first medical AI startups to receive approval by the United States Federal Food and Drug Administration for some of its medical algorithms helping clinicians detect coronary artery disease.

Within cyber, the academic spin-off of Bar-Ilan University, Unbound tech, has created a solution that allows users to work with confidential information without exposing it, ensuring the safety of their digital assets. Founded by Prof. Nigel Smart, Prof. Yehuda Lindell together with industry veterans Avner Mor and Guy Peer, the company which was started on a USD 2 million Horizon 2020 grant, has since raised an additional USD 14 million and employs approximately 40 staff.

6. AI start-ups in Israel

One of the areas that Israel is most known for internationally is its vibrant start-up scene. As this chapter will show, despite being only a sub segment of the entire start-up scene, Israel's AI start-up scene can be described as thriving, mature and interdisciplinary with many companies working at the intersection of multiple technologies (for example cyber and AI). Many of the start-ups are so-called "born global" whereby they compete globally from day one, usually with a particular emphasis on expansion to the US market. To support the creation and growth of these start-ups, a variety of incubators as well as strong government and private funding exist. After a long period of start-ups being sold to foreign companies in technology acquisitions, there is now a growing trend of start-ups maturing to fully scaled companies in Israel, often with major operations in the areas of sales and marketing abroad.

6.1 Number of AI start-ups Israel vs. Denmark

While the previously mentioned consortium around Roland Berger and Venture Capital Firm Asgaards counts only 362 "pure" AI start-ups in Israel⁴³, the Israel Venture Capital Research Center that was tasked by the authors to conduct research exclusively on AI start-ups in Israel, finds close to 1'000 currently active companies in AI in Israel. This includes those companies whose products find themselves at the intersection of AI and cyber, AI and fintech, etc. The actual number is likely to lie somewhere in between and is heavily influenced by definition criteria.

In contrast, Nordic AI, a non-profit active in bringing visibility to Danish and Nordic start-ups with a focus on AI counts as well as a reference check on Danske Hub, where many Danish start-ups host a profile reveals approximately 50 start-ups in the fields of data science, machine learning and artificial intelligence, the majority being in early stages of development.

Since the data by the Israel Venture Capital Research Center is much more detailed than the previously mentioned consulting report, the following paragraphs are based on this data.

6.2 Growth of AI start-ups as a category

Beginning a new wave of growth in 2010, the annual rate of AI companies established has accelerated and almost tripled in each of the last four years compared with the annual rate at the beginning of the decade. More than 1,200 AI companies have been established, of which 79% or 954 are still active, 6% have been acquired, and 15% have ceased operations. The number of newly established companies each year marks the pace of growth in the industry. In 2014 – 2016, more than 500 companies joined the AI group in the Israeli tech and bring the total amount of companies to double in a very short period. The pace of growth slowed in 2017, and is expected to continue to slow in 2018, following the over-hyped investment cycle in AI companies across the globe. Similarly significant is the large pipeline of start-ups that are aggressively aiming to become the AI market leaders of tomorrow. "The Tel Aviv metropolitan

⁴³ Definition of AI start-up retrieved from page 5 of <https://asgard.vc/wp-content/uploads/2018/05/Artificial-Intelligence-Strategy-for-Europe-2018.pdf>

area probably has the highest concentration of AI start-ups anywhere in the world,” states Eli Nir, senior investment partner at OurCrowd, a leading Israeli venture capital fund. Indeed, a recent analysis⁴⁴ revealed that over 80% of all Israeli AI start-ups can be found in the Tel Aviv region as can be seen in the exhibit. Areas experiencing significant growth in AI startups are Haifa, Jerusalem and Beer Sheva.

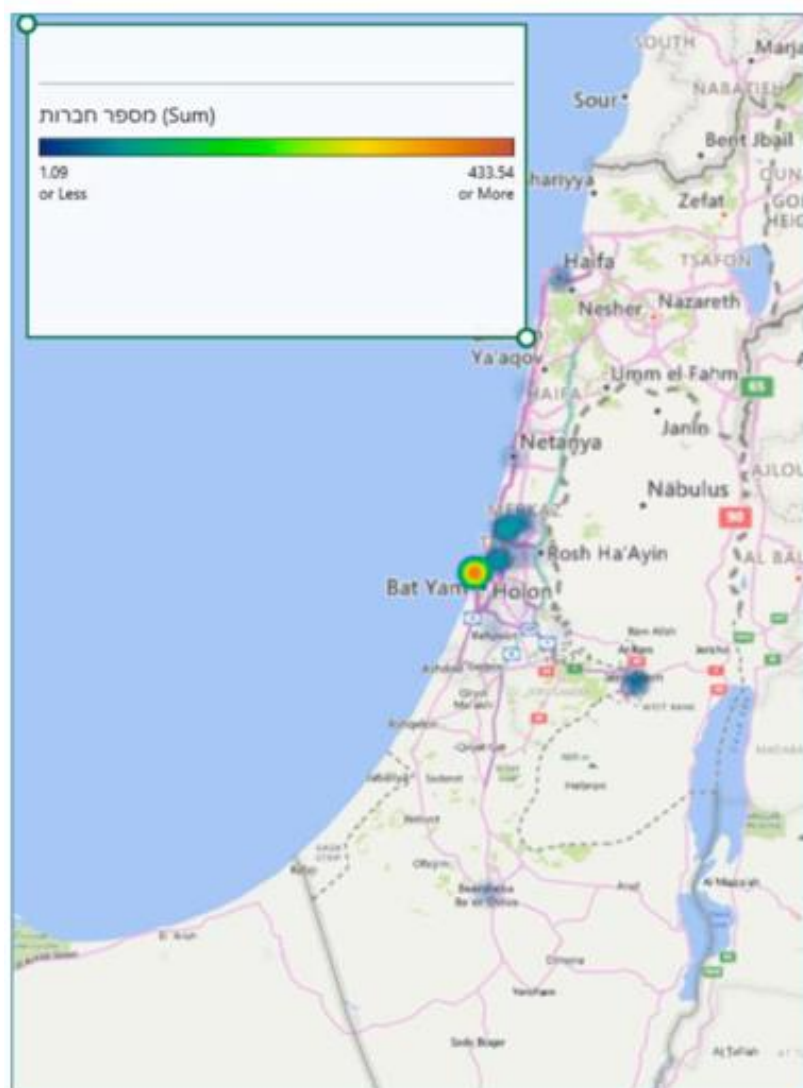


Exhibit 12: Geographical location of AI startups across Israel

In terms of company stage, Israeli AI companies can be divided into three stages:

- Early Stage – a startup company which is in its early days of R&D and fund raising, usually not more than three years since the first funding.
- Initial Revenues – a company at the beginning stage of sales, whose estimated annual

⁴⁴ Based on data by Startup Nation Central and performed by the Samuel Neaman Institute.

- revenue does not exceed \$10 million.
- Revenue Growth – a company whose estimated annual revenues exceed \$10 million.

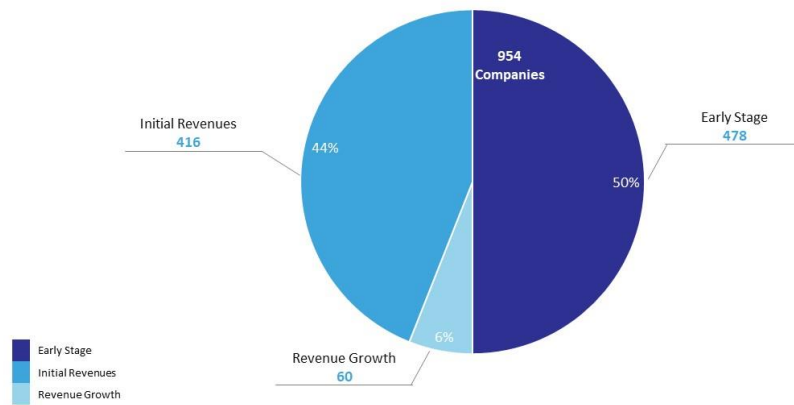


Exhibit 13: Stage of Israeli AI startups reflecting the growing nature of the sector

From a corporate Danish perspective, especially the companies in the phases of “initial revenues” and “revenue growth” are of particular interest since they mostly have a business to business focus and are eager to engage with corporates.

6.2.1 Civilian Incubators

Common to many of Israel’s start-ups and similarly correct for the AI subsegment is that many of them have been formed in and around the large number of incubators and accelerators in Israel. In contrast to Denmark, many of such outlets are run as for-profit entities however the business models, goals and operations of the incubators vary widely depending on the institutional backing. There are also government financed incubators aimed to lift up industries with high potential where Israel has not yet become a global leader (for example bio-tech).

These mostly operate outside of metropolitan areas and are not further addressed in this report.

A selection of leading private incubators in the field of AI can be found in the exhibit.

Name	Verticals	Provided support	Backed By
Microsoft ScaleUP TLV	SaaS, AI, cyber	Mentoring, access to business tools	Microsoft
Drive:TLV	Transportation technologies, autonomous driving	Mentoring, access to corporate backers	Honda, Volvo, Hertz, NEC, iTuran, Aptiv, Mayer
The Junction	SaaS, AI, cyber	Finance, mentoring,	Genesis partners venture capital fund
SOSA	Homeland security, Construction, Fintech, ICT	Direct access to 80+ corporates globally, office space	Senior business angels
Samsung Next	IoT, AI	Finance, mentoring	Samsung
The Floor	Blockchain, Fintech	Finance, mentoring, corporate incubation, access to 6 of 10 biggest banks worldwide	Fosun Group
Barclays Techstars	Fintech, Insurtech	Finance, mentoring	Barclays, others
8200 EISP – Elite military unit	Wide variety with deep technology footing	Mentoring, networking	Non-profit

Exhibit 14: selection of leading Israeli incubators in the field of AI

6.3 Military incubators

The security apparatus and its agencies are highly innovative in the way it collaborates with industry and start-ups. As such, the Israel Security and Intelligence Service (Mossad) is operating a start-up incubator called Libertad ventures⁴⁵ looking to partner with start-ups in the fields of robotics, encryption, natural language processing and text analysis as well Web intelligence among others. The incubator offers up to NIS 2 mio. in equity free funding. In a similar fashion, Shin Bet, the Israel Security Agency has partnered up with Tel Aviv University and provides USD 50'000 in equity free funding. A newspaper article writes⁴⁶: "The program's first cycle, which launched in May, hosted seven start-ups and focused primarily on artificial intelligence and data science technologies. Director General of the Israel Security Agency, Nadav Argaman, said in a statement that products from last year's accelerator cohort "already affect the capabilities of the Shin Bet and its activities."" For both programs, there are no immediate return expectations except for non-exclusive rights to the Intellectual Property developed. The Air Force also operates an incubator which may house AI related projects.

6.4 Israel based AI start-ups taking on global markets

Often called the "start-up nation", the Israeli ecosystem has in recent years made a strong effort to not just start companies and sell them for several hundred million dollars to foreign corporations, but to scale up these companies with the core functions remaining in Israel. This

⁴⁵ <http://www.libertad.gov.il/eng/>

⁴⁶ <https://www.calcalistech.com/ctech/articles/0,7340,L-3751229,00.html>

has resulted in a number of unicorn companies, whereby some of the ones with a strong AI component can be found in the exhibit below. What differentiates these companies from their US or Chinese counterparts is that the way they conduct their businesses often leads to strong bilateral operations. Many of today's market leaders, in addition to their offices in Israel, have a strong presence in close physical proximity of their customers, f.e. in the US or in Europe.

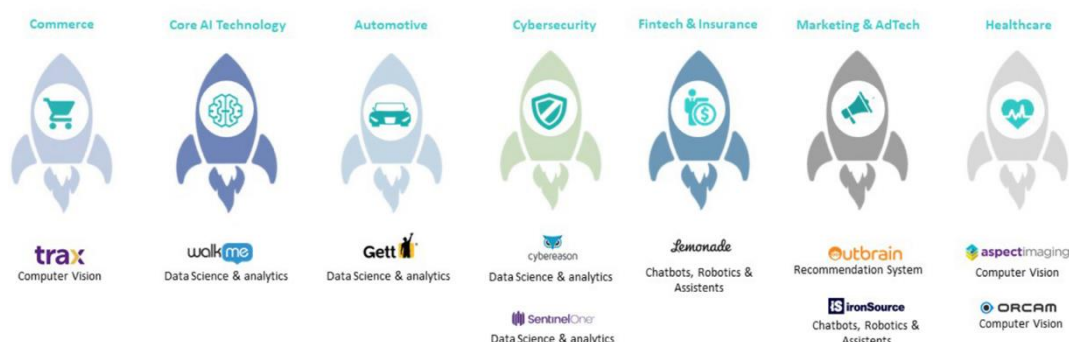


Exhibit 15: Israeli AI market leaders

6.5 The financing supporting these start-ups

The above market leaders are usually venture capital financed and have attracted significant amounts of capital. The upward trend has continued in the first three quarters of 2018 with more than 20 companies attracting over \$30 million in financing each. Some of the largest rounds in the space over the past year included: \$125 million by Trax, \$120 million by Lemonade, \$100 million by eToro, \$41.4 million by OrCam Technologies and \$33 million by Riskfield.



Name	Raised	Date	Vertical
	125 \$M	July 2018	Commerce
	120 \$M	December 2017	Fintech
	100 \$M	March 2018	Fintech
	100 \$M	June 2017	Cybersecurity
	80 \$M	June 2018	Automotive
	75 \$M	November 2018	Core AI Technology
	75 \$M	July 2017	Core AI Technology
	70 \$M	January 2017	Cybersecurity
	70 \$M	July 2018	Healthcare
	55 \$M	September 2018	Homeland Security

Exhibit 16: Largest financing rounds of AI companies in Israel 2017-2018

6.6 Exits & venture capital funds in Israeli AI

Venture capital for local AI companies is plentifully available and companies are in close contact with investors. "The deal flow has been running at around 80 proposals a month," says Yori Nelken, general partner at Cognitiv, an early stage AI fund. Nir estimates that as much as 80% of the fund's investments have been in start-ups with an AI component. There has also been a parallel increase in the amount of deals and funds raised. The latter has nearly quadrupled from DKK 2.3 billion in 2013 to more than DKK 10.5 billion last year while the number of deals has more than doubled to 216 over that same period. The reasons for this strong increase in available capital can certainly be found in the overall excitement over the category globally but also in the strong returns generated by Israeli companies in recent years as can be seen in the exhibit. Most of the capital is from foreign sources (>90%) something that the Israeli government is working to change in order to enable Israel to also benefit from the capital interest associated with strong commercial performance.






Name	Exit Amount	Date	Vertical
 MOBILEYE	15,300 \$M	2017	Automotive
 datorama	850 \$M	2018	Marketing & Adtech
 vizrt	374 \$M	2014	News & Media
 Kontera	150 \$M	2014	Marketing & Adtech
 CONTROP <small>Turning Vision Into Reality</small>	95 \$M	2011	Homeland Security

Exhibit 17: Excerpt of some of the largest exits in the Israeli AI landscape (excludes other exits in similar size to show breadth of AI space in Israel)

Israeli Investors can be considered aggressive on AI with several investors having invested in 10+ deals in the category during the period of 2017-2018.





Top Investors by First Investment in AI	Investor Type	Capital Managed	# of AI Deals in Participation	Average Deal \$M	# of AI First Investments
 MANIV <small>MOBILITY</small>	VC Fund	40	13	5.9	7
 OurCrowd	Angel Club/ Group		12	13.7	7
 Angels	Angel Club/ Group	50	11	7.6	4
 vertex <small>VENTURES</small> Vertex Israel IV Fund	VC Fund	150	10	9.9	7

Exhibit 18: Most active Investors ranked by the largest number of total investments in Artificial Intelligence companies during 2017-2018

7. Multinational Corporates active in AI in Israel

Over 350 multinational corporations operate research & development centres in Israel. This large number is owed to historically high financial incentives by the government, the high quality of talent and other factors. In many cases these centres were established upon the purchase of a local technology company and subsequently grew over the years. Owing to these developments, an ever-growing number of these corporates are also active in the field of AI in Israel representing a variety of industry verticals⁴⁷. While the setup of each corporate operation is somewhat different, many elements are shared. Among them is the strong focus on working with the local ecosystem, whether with start-ups, universities or the government. In most cases, the engagements grow significantly over time. As stated in the previous chapter, many corporates in addition to their R&D departments therefore operate start up incubators, accelerators and other facilities whether by themselves or in collaboration with other stakeholders.

7.1 Acquisitions of Israeli AI by multinational corporations

An example of such an engagement in the AI space was displayed in March 2017 when Intel bought Mobileye for a record \$15.3 billion, the largest ever acquisition of an Israeli company. The company started by AI professor Amnon Shashua of Hebrew University and the purchase of the Jerusalem-based developer of sensors and artificial intelligence driver assistance systems was designed to position Intel as a leading player in the fast-growing autonomous vehicle market. The ripple effects of that deal led to Israel becoming a major global centre for AI technology in the automotive field with the space quickly being filled with start-ups, dedicated venture capital funds, incubators and accelerators as well as Hebrew University becoming known as a leader in this field. In a similar fashion, corporates have for years been active in acquiring start-ups in order to improve their capabilities in AI. The exhibit portrays some of the most significant acquisitions in the field of AI.

⁴⁷ Data retrieved on January 16 from <https://startuphub.ai/ai-talent-pool-in-israel-from-multinational-corporations/>

Top Israeli AI Startup Acquirers

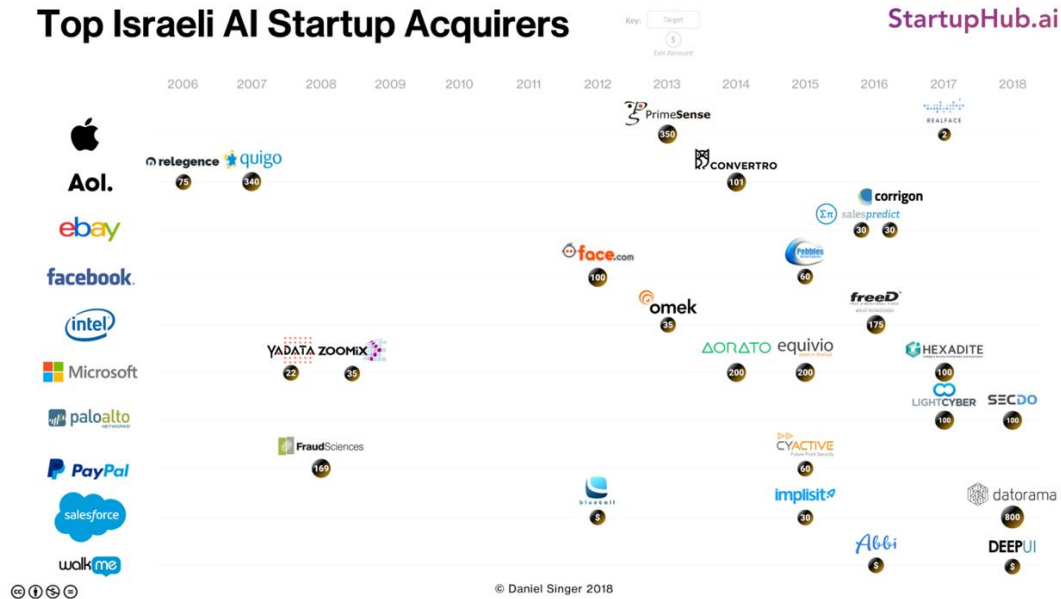


Exhibit 19: Acquisitions of Israeli AI companies by multinational corporates 2006 – 2018⁴⁸

The following six acquisitions shall provide a more in-depth insight into the frequent AI acquisitions by multinational corporates in Israel:

- PrimeSense acquired for \$350 million in November 2013 – Founded in May 2005 by Aviad Maizels, Alexander Shpunt, Dima Rais, Ophir Sharon, and Tamir Berliner, PrimeSense developed hardware and chips that enabled three-dimensional computer vision sensing of a user, and which learns and understands user movement within those surroundings. It's technology originally powered the Microsoft Kinect product, and was acquired to enable, in a miniature form and to a certain degree, facial recognition on the iPhone. PrimeSense had raised nearly \$80 million in total funding.
- Datorama acquired by Salesforce for \$800 million in July 2018 – Founded in June 2012 by Ran Sarig, Efi Cohen and Katrin Ribant, Datorama used machine learning for its marketing integration engine which automates the collection of data sources. Datorama raised \$50 million in total funding.
- FraudSciences acquired by PayPal for \$169 million in January 2008 – Founded in October 2001 by Saar Wilf and Shvat Shaked, FraudSciences used machine learning to automatically detect and classify fraud for merchant solutions. FraudSciences raised \$11 million in total funding.
- Replay Technologies acquired by Intel for \$175 million in March 2016 – Founded in November 2011 by Oren Yogev, Mateo Shapira, and Aviv Shapira, Replay Technologies developed FreeD technology, its proprietary image processing and computer vision algorithms that synchronizes all images captured from an array of cameras and render a resulting in 360-degree image for ultimate replay viewing. The company raised \$27 million in total funding.
- Face.com acquired by Facebook for \$100 million in June 2012 – Founded in June 2007 by Yaniv Taigman, Eden Shochat, Gil Hirsch, and Moti Schniberg, Face.com developed facial recognition technology of photos using machine learning methods. The company bundled their technology into two apps on Facebook called Photo Finder and Photo Tagger which automatically scanned Facebook photos to suggests tags for untagged faces. The company raised \$5.8 million in total funding.

⁴⁸ Graph retrieved from: <https://startuphub.ai/top-israeli-ai-startup-acquirers/>

- SalesPredict acquired by eBay for \$30 million in July 2016 – Founded in July 2012 by Kira Radinsky and Yaron Zakai-Or, SalesPredict leveraged machine learning and advanced analytics to predict and identify customer purchasing intent and sales conversions. The company's artificial intelligence technology was used to bolster eBay's structured data efforts of product catalogue data. SalesPredict raised \$5.1 million in funding.

Daniel Singer, a research analyst covering AI in Israel estimates that of the over 4'000 AI professionals in Israel "over 30% are employed by multinational corporations, across over 65 multinational corporations with dedicated AI research and development situated in Israel. Intel and IBM together account for nearly one third of the entire AI talent pool employed by multinational corporations." Many of these employees have become so through technology acquisitions.

- Intel – approximately 280 dedicated AI professionals working at Intel Ra'anana and Haifa campuses, operates a research Center in collaboration with the Technion launched in October 2018, likely several hundred additional AI professionals due to acquisition of Mobileye.
- IBM Research – Haifa – approximately 130 dedicated AI professionals working alongside other disciplines in its research center in Haifa, making it the largest lab worldwide of IBM Research Division outside of the United States.
- Google AI Research Center Israel – approximately 50 AI professionals working alongside several hundred engineers in Israel.
- Apple Israel Ltd. – approximately 65 AI professionals in Israel.
- Nvidia – opens a new AI research center on October 2018, recruiting at least 10 AI experts in the first stage.
- Microsoft – approximately 50 AI professionals working alongside several thousand engineers in Israel, leading AI engine Cortana and others.
- Samsung – approximately 50 AI professionals, in addition operating Samsung Next, early stage venture fund in AI & IoT.
- Amazon – approximately 70 AI professionals working alongside several hundred engineers in Israel, leading global Alexa Shopping, Alexa Voice, Robotics after purchase of software startup Annapurna Labs for USD 350 mio. in 2015.
- GM – approximately 60 AI professionals working alongside several hundred engineers on domains such as cyber, autonomous driving among others.
- Verint – approximately 50 AI professionals.
- Applied Materials – approximately 45 AI professionals.

The Samuel Neaman Institute reports that these R&D centres are particularly productive: "The total number of distinct applications for AI patents applied by Israeli applicants increased by an average of about 10% per year between the years 2000-2014. Applied Materials (Israel) leads the Israeli companies in the number of distinct patent applications, with IBM leading in number of patent applications by multinational companies with R&D centers in Israel. Patent applications in AI for Israeli applicants, Israeli inventors and non-Israeli applicants (at least one Israeli inventor) increased by approximately 400% over the period of 2000-2015." (Numbers for Denmark not immediately available).

8. Conclusion

Taking all the elements into account required to be a leader in artificial intelligence in the 21st century this report has shown that Israel is a strong player in the global arena while being aware of the challenges it faces as a small nation amid strong competition from small and large countries.

Since Israel is a small open economy, the developments in AI in Israel seem particularly applicable to the Danish context.

It would be beyond this report to suggest specific ways of collaboration between Danish and Israeli stakeholders working on AI but it is the hope of the authors that the report has contributed to an increased interest in such collaborations where they are deemed beneficial to both parties.

The authors of this report additionally hope that by shedding light on the developments in Israel, some of the challenging upcoming decisions as it relates to Denmark's national AI strategy can be taken from a more informed point of departure.