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ARTIFICIAL INTELLIGENCE MANAGEMENT: A GLOBAL OVERVIEW AND THE CASE OF STITCH FIX, INC.

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“We can only see a short distance ahead, but we can see plenty there that needs to be done.”

Alan Turing

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1. INTRODUCTION

Artificial Intelligence is arguably one of the most advanced, fascinating, historically idealized and ambitious technology that evolved in these two first decades of the third millennium. The aim of this thesis is to describe what are the main features of the broad Artificial Intelligence universe, and especially to investigate current business applications as well as future social prospects related to this subject.

This analysis is divided in 5 main section: after the general introduction, the second section briefly summarises the milestones of AI's history and outlines the major technologies that are directly associated with the concept of AI, providing also some examples real-life employment of such technologies;

The third section, instead, analyses how AI is currently integrated by companies in their business activities; the second part of this section focuses on AI employment in the retail industry, and the benefits it could bring to many segments of a retailer's value chain. Next, section 4 analyses the possible social impact that new advanced technologies may have soon.

Finally, section 5 will be entirely dedicated to the business case analysis of Stitch Fix, Inc., an emerging American company that is currently trying to disrupt the fashion retail industry adopting a data science and AI-centered business approach. The case of Stitch Fix demonstrates a practical application of many concepts covered in the previous section.

2. THE CONCEPT OF AI

2.1 History of AI

The origin of Artificial Intelligence was characterized by many efforts made in different disciplines. Naturally, early projects in scientific fields such as electronics and engineering are considered milestones for technical development of AI. The first significant studies regarded some concepts that numerous people and institutions worldwide are familiar with nowadays, like problem solving, language understanding and translation, associative memory.

Along with scientific progresses, also literature and the expanding audio-visive industry has contributed to further awareness and curiosity towards AI. Throughout history, various science fiction writers have depicted the possibility of intelligent machines, mainly with the scope of making a reflection on what is the real essence of being human; the Russian/American writer Isaac Asimov was probably the most iconic exponent of the proper sci-fi genre that born and expanded in the twentieth century, but also works from writers like Jules Verne and L. Frank Baum[1] in the previous century inspired interest in AI. Baum, in particular, created the character of Tik-Tok (1907), imagined as an "*Extra-responsive, thought-creating, perfect-talking Mechanical Man* [...] *Thinks, speaks, acts, and does everything but live*"[2].

From a pure scientific perspective, the first research paper that drew attention to the possibility of "thinking machines" was presented in 1950 by Alan Turing with the title "*Computing machinery and intelligence*"[3]. Turing's hypothesis exposed both scientific and philosophic implications that were considered extremely relevant and have always constituted a solid foundation for the whole academic literature regarding AI. Focused around the description and the development of game that still today is called "Turing's Test" or "The Imitation Game", the paper presents an intriguing prospect of

[1] Lyman Frank Baum (1856-1919) was an American writer. He is widely renowned for the book "The Wonderful Wizard of Oz" that started the Oz book series.

[2] The character of Tik-Tok first appeared in "Ozma of Oz", 1907, the third book of the series. It is considered among the first "robots" presented in modern literature (Raylyn Moore: "*Wonderful Wizard, Marvelous Land".* OH, Bowling Green University Popular Press, 1974.

[3] Alan Turing's paper "*Computing machinery and intelligence*" was published by Mind (A Quarterly Review of Psychology and Philosophy), Vol. LIX, No. 236, Pages 433–460, October 1950.

building and programming machines that would eventually play the imitation game so well that they are indistinguishable from humans.

Generally, it is a complex task to determine precisely the exact date for the birth of a new scientific research field. Nevertheless, there is a general agreement upon the fact that the Dartmouth Summer Research Project of 1956 was the event that instituted AI as a research discipline.

John McCarthy, Professor of mathematics at Dartmouth in that period, was the first who got credits for coining the word Artificial Intelligence and channelling the projects' focus. Even though the Dartmouth conference is considered a crucial starting point for the study and development of AI, in practice there was little coordination and collaboration between the participants, the majority of whom continued to work mainly on personal projects. There was not any agreement on the core principles that should have directed this new field of research, what was the basic theory to follow and the challenges to tackle.

The only concept shared by all members was the belief that computers could have been constructed to produce intelligent behaviour. Such vision was clearly highlighted by the proposal for the conference that stated: "*The study is to proceed on the basis of the conjecture that every aspect of learning or any another feature of intelligence can in principle be so precisely described that a machine can be made to simulate it*". Such proposal is analogous to the actual definition of AI given by the English Oxford Living Dictionary: "*The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making and translation between languages*".

In this definition are listed few but representative tasks that AI has the potential to perform effectively at the present time. Now, these two statements could make us wonder what are the real components of human intelligence that can be decomposed in specific settings with which a machine have to be developed. Initially, there was expectations that a small number of precise and powerful methods could be recognized and eventually adopted to create smart programs.

In the formative years of the field, it was given paramount importance to research and theorem proving, as explained by Ira Goldstein and Seymour Papert (1977)[4]. The two experts highlight how between the 50's and 60's AI was being identified as the science of heuristic search, namely a technique aimed at solving complex problems faster than traditional methods, at the cost of losing accuracy and optimality in some cases. Proceeding through 70's there was a clear change of this criterion.

[4] Goldstein I., Papert S. *"Artificial intelligence, language, and the study of knowledge".* Cognitive science, 1977, Elsevier.

The principal challenge of explaining intelligence was not the selection of few dominant approaches. Instead, it gained prominent importance the question of how to express large volumes of knowledge in a functional way that could have permitted a proper interaction and use of such volumes.

This shift of paradigm is summarized by the transition from a power strategy to a knowledge-based approach, as described by Marvin Minsky[5]: while the power strategy is based on a constant and uniform increase in computational power that is independent from the data base to which it applies, the knowledge strategy views progresses as the result of better approaches to recognize, express and deliver different categories of knowledge. According to Minsky and shared by Goldstein, this latter doctrine defines the problem as an epistemological matter, rather than a question of computational power or mathematical expertise. It is a line of thought that overlaps technology with anthropology and philosophy, since it leads to the conclusion that an intelligent person might exhibit particular abilities due to his/her abilities in organizing knowledge, rather than having better global qualities of thinking in terms of pure speed and power.

Moreover, Minsky argues that such global qualities of thinking are quite similar if we compare an adult and a child, save for the results of self-applied knowledge. Of course, no person can be deemed as intelligent without carrying a basic "hardware" capacity, yet this paper shares the belief that this capacity is already established in a young child. The ensuing development of intelligence is due to acquisition and preservation of knowledge and not to the advent of new biological capabilities.

This kind of reasoning had several implications regarding the possible improvements that AI could have brought to the education system. Such implications were studied[6] and tested throughout the 80's and 90's, when new educational tools like ITS (intelligent tutoring systems) were first adopted in schools. ITS subsequently evolved into ILEs (interactive learning environments) in response to a changing educational landscape where the automation of traditional teaching and learning methods contributed also to redefine established educational goals: if new technologies can automate classic activities like spelling correction and algebra exercises, these skills become less important to learn, while skills of higher rank like those required for creative mathematics and writing acquire more importance. An ILE is formed by various tools that are not controlled by a tutor, in a fashion that encourages students to learn by construction instead of instruction: the tutor has the mere role of a guide, while students can manage the learning process, and determine the degree of individualization.

[5] Minsky M., Papert S. "*Artificial intelligence".* Condon Lectures, Oregon State System of Higher Education, Eugene, Ore., 1974.

[6] McArthur D., Lewis M., Bishay M. "*The roles of Artificial Intelligence in education: current progress and future prospects*". Journal of Educational Technology Volume 1, Number 4, 2005.

The scope of such technologies is to put into practice a process of teaching and learning that is based on inquiry, in order to make students grasp a deeper understanding of concepts that are often taught as mechanic exercises. In the last decades, we have observed a constant enhancement of different technologies related to teaching/learning. However, the full practical adoption of these instruments obviously requires scale and the coordination between educational institutions: since new technologies help discover new goals, it is consequently more difficult to evaluate results when the standards are changing as well. Nowadays, several countries are expressing the necessity of educational reforms in order to design and exploit an effective synergy between technology, assessment criteria and teacher pedagogy.

Proceeding through the last decade of the 20th century, AI researchers concentrated their efforts into complex games such as chess and "Go" in order to study logic representation and inference mechanisms. Another important turning point in the history of AI was reached in 1997 when the Deep Blue program, projected and developed by IBM, defeated the world chess champions Gary Kasparov, the first time ever for a machine[7].

In 2006 was celebrated the 50th anniversary of the Dartmouth College Summer Research Project[8], recognizing the large amount of results achieved in the field of AI, that range from the prodigious progresses in robotics to the extensive adoption of language recognition in different area of people's everyday life. Despite the undeniable success of AI in these last decades, even nowadays the methodologies adopted by researchers may vary consistently and there are distinct areas of research within the main field that hardly cooperate. If during the 70s there was the "knowledge versus power" conflict, the debate today has slightly shifted to a logic-based versus probability-based concept of AI. Supporters of the probability-based view have mentioned how the latest advancements in language processing are the result of statistics methods overtaking natural language processing.

As the number of current AI applications that can imitate human actions is increasing, the confrontation between psychology and pragmatic view has gained prominence. Advocates of the psychology current believe that AI should follow psychological principles if in the future will be obtained a human-like level of AI, whilst other scientists are more disposed to discover the results of AI systems that go beyond the established canals of human psychology.

Trenchard More, John McCarthy, Marvin Minsky, Oliver Selfridge and Ray Solomonoff were the only researchers that attended both the 1956 and 2006 Dartmouth Conference: they have been constant

[7] McCorduck, P. "*Machines Who Think: Twenty-Fifth Anniversary Edition"*. Natick, MA: A. K. Peters, Ltd., 2004.
[8] Moor, J. "*The Dartmouth College Artificial Intelligence Conference: The Next Fifty Years*". AI Magazine, *27*(4), 87, 2006.

contributors to the development of AI and witnesses of the ideology divergences mentioned before. Even when asked about possible scenarios for the future of AI, they showed different perspective: McCarthy offered the prospect of a human-like AI capacity by 2056, Selfridge stated that machines will integrate sensations and feeling in their behaviour, whilst Solomonoff drew the attention on the eventual political implications of achieving extremely smart AI systems.

The speed of improvements in performances along with the number of AI practical applications has drastically increased starting from the new millennium's dawn to the present days, as testified also by the growing importance that AI and the phenomenon of automation are having in the public debate. Currently, the most effective AI applications include smart automation, advanced analytics, smart automation, augmented creativity and reality, simulation, natural language processing, recognition of images/videos/speech, etc.

It is evident that the public opinion has also concentrated on the possible drawbacks of a future scenario where automation will be more and more prominent. In order to address these issues, the sections 3.2-3.3 will investigate what are the possible future socio-economic scenarios that may characterize numerous nations in the next decades, following the expected increase in the percentage of jobs that will be automated.

2.2 AI-related technologies and applications

Before proceeding to present and assess the most significative current applications of AI and their socio-economic impact, it is necessary to provide a precise definition of what it is the modern definition of AI and other important technologies that are correlated with it, such as Machine Learning, Deep Learning and the Internet of Things. These words are increasingly used not only in scientific publications but also in university lectures and newspaper articles, thus becoming an integrant part of new generations' vocabulary. This section will briefly present such concepts in order to establish a basic framework that can help better visualize and understand the broad universe of AI.

Artificial Intelligence*:* I have already conveyed two famous definition of AI, one from the proposal of the Dartmouth Research Project where the word was first coined, and the other from English Oxford Living Dictionary. Notwithstanding, these days experts make an additional distinction between weak and strong AI; if both types can perform activities that comprise many aspects of human cognition (such as reasoning, perception, planning, decision making etc.), only systems that deploy strong AI

have functions capable of adapting to changing circumstances. Weak AI just performs the same activities but does not learn from its own previous actions. The key process that differentiate a strong AI from a weak one, is the Machine Learning (ML) concept.

***Machine Learning**:* since the evolution from ML to AI is determined by a fluid process, these two terms are often used as synonyms, particularly in the business field. The ML process describes a situation in which algorithms (that can be considered as the DNA of any AI system) are "self-learning" (i.e. adaptive to deviations in their framework). Such algorithms can automatically learn further about certain properties of the data with which they are working, thus empowering a more conscious AI in performing activities like prediction of outcomes or pattern recognition. Naturally, the process of automated learning is not as simple in practice as it appears.

Three forms of learning coexist within ML: supervised learning, unsupervised learning, reinforcement learning; the difference lies in how the response is given. For example, a combination of unsupervised and semi-supervised learning is the basis of progresses in computer vision that are essential for the development of collaborative robots. In order to be prepared for an effective use, Machine-learning algorithms require a substantial training with a huge quantity of data to improve performance.

Such training is essential to enable the inference process, namely that phase when the educated algorithm is capable of predicting the most congruent output from previously unknown data. This is the reason why ML techniques are extensively used for predictive maintenance (i.e. the process of learning from previous situations and recognizing certain patterns from a specific database, in order to predict and prevent future machines' failures in production.

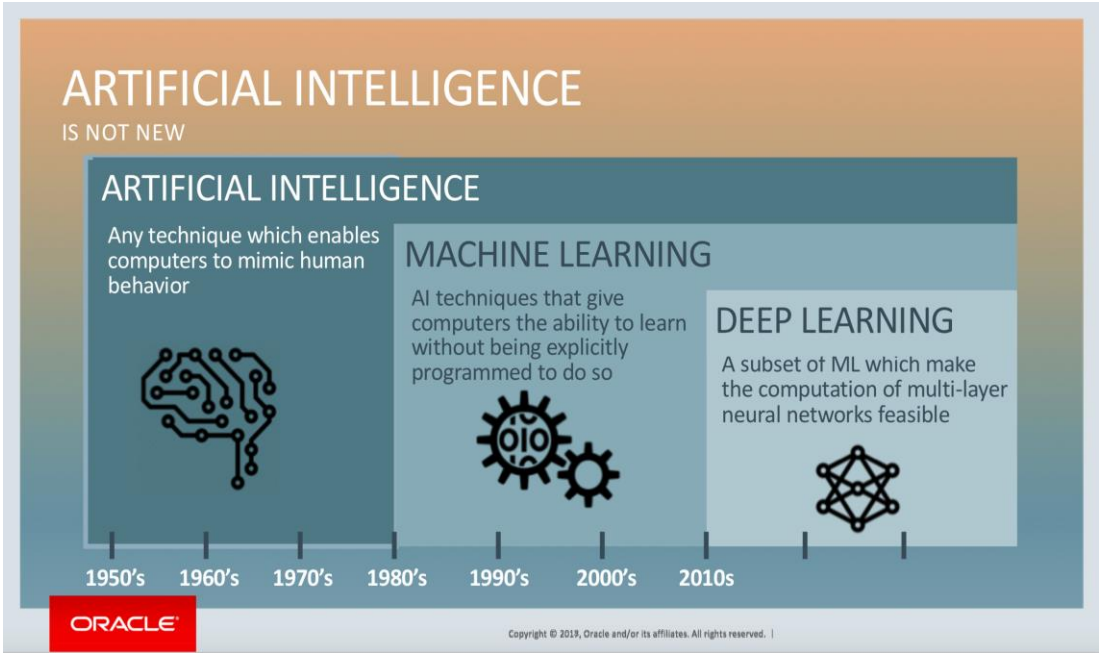
***Neural Networks**:* They are computing schemes composed by many processors (called nodes) that display a vague resemblance to the system of neurons in a human brain. Such nodes are disposed in numerous different layers and trained with huge volumes of data.

The principal aim of Neural Networks is to solve complex pattern-recognition tasks, which is the reason why they are currently enjoying a fruitful commercial application for handwriting and facial recognition. Neural Networks are the core structure at the foundation of Deep Learning.

***Deep Learning**:* Deep Learning (DL) is a subset of ML that works a with more consistent neural network formed with numerous levels of neurons; it is aimed at solving more complex tasks. For example, DL is also used by logistics robots to learn how to identify the position of specific objects in a store and recognize when an item is removed from the shelf.

This is how Amazon has introduced a ground-breaking new concept of retail supermarket called Amazon Go[9], in Seattle. Customers can select the desired items from the shelves and walk away without stopping at the check-out point. The store is equipped with advanced computer vision technology (enabled by DL) that is applied to recognize a precise customer and associate him with the goods he has taken from the store. When a client leaves the supermarket, Amazon reports the total expenditure in the user's account and send him an e-mail with the receipt of the payment.

The case of Amazon is just one example about how AI-related technologies can disrupt further the retail sector specifically, as will be described in the section 3.2. Another incredibly peculiar case of DL application involves a Japanese systems designer for the automotive industry and his parents' cucumber farm: Makoto Koike, tired by the time-consuming task of sorting cucumbers by colour/shape/size, exploited Google's Tensor Flow[10] (an open source library for ML) to invent a computer-based instrument that is able to effectively rate cucumbers' quality.



Source: https://blogs.oracle.com/bigdata/difference-ai-machine-learning-deep-learning

[9] https://tinyurl.com/Amazon-Go-supermarket
[10] https://tinyurl.com/farmer-uses-deep-learning

***Internet of Things**:* The recent breakthrough of Wireless Sensor Network (WSN) has enhanced the application of ubiquitous sensing technologies in many aspects of contemporary life. Such technologies are embedded in devices that are able to assess, understand and draw conclusions from a vast amount of data provided by environmental indicators. When these instruments communicate and operate invisibly in a single network integrated with the surrounding space (which becomes a "smart environment"), they create the Internet of Things (IoT), a framework where the information gathered by different devices are shared through platforms to build up a "Common Operating Picture" (COP).

Since the notion of IoT includes so many different technologies and technical implications, it would be very ponderous to describe it in the specific. A basic but clear definition is given by Jayavardhana Gubbi and his colleagues[11]: they define IoT for smart environments as the interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a COP for enabling innovative applications.

Such outcome is obtained with data analytics, unified large-scale sensing, along with a state-of-the-art ubiquitous sensing and cloud computing aimed at delivering an effective representation of information. The range of possible applications varies from personal (health) and home (appliances) control, to transport management (vehicles, traffic and infrastructure monitoring) and environment preservation (supervision of water and pollution).

From a business perspective, IoT offers the opportunity of developing new business models by leveraging improved operational effectiveness and reinventing costumer experience. Many companies are currently adopting an "omnichannel" strategy for their customers' experience, which means that a user can interact and utilize a certain service from different platforms and devices; IoT is the major instrument for implementing such strategy.

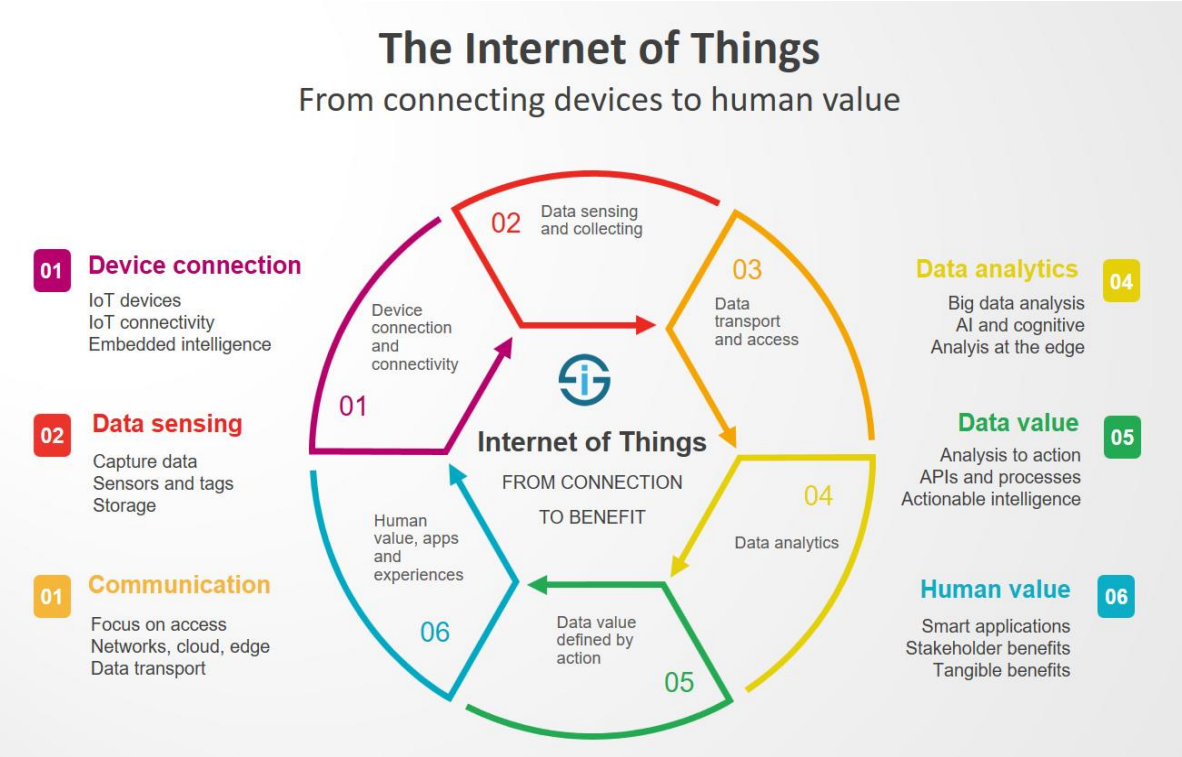
A famous example is represented by Amazon's Alexa, a new genre of computing interface that performs the role of personal assistant: it listens to costumers' needs and requests, it gathers data about preferences and habits, it responds vocally and proposes solutions. Furthermore, this case solidifies further the customer-centric view of business that has always been pivotal for Jeff Bezos' concept of leadership ("Leaders start with the customer and work backwards").

[11] Gubbi J., Buyya R., Marusic S., Palaniswami M. *"Internet of Things (IoT): A vision, architectural elements, and future directions".* Future Generation Computer Systems, Vol. 29, Issue 7, pp. 1645-1660, Elsevier, September 2013.

Another distinguished case was provided by IBM, which in 2016 choose to invest $200 million USD to develop a global headquarter for its Watson IoT business[12] in Munich, as part of a total investment of $3 billion USD. The technologies incorporated in Watson apply advanced ML techniques and natural language processing to draw useful information from data shared by devices connected in the IoT framework. In 2016, IBM stated that the number of clients that were using Watson services increased from 4,000 to 6,000 in just 8 months, thus confirming the willingness of both costumers and business to modify their habits and operations through a blend of IoT and AI technologies. Furthermore, in 2016 the doctors from University of Tokio have reported that Watson identified a rare form of leukemia in a 60 years old woman, while her doctors tried for months to find a correct diagnosis[13]. Allegedly, the IBM's supercomputer was able to achieve such result by comparing patient's genetic changes within a database of 20 million research papers.

[12] https://tinyurl.com/IBM-Watson-IoT

[13] https://www.healthcareitnews.com/news/ibm-watson-pinpoints-rare-form-leukemia-after-doctors-misdiagnosed-patient



Source: https://www.i-scoop.eu/internet-of-things/

3. AI adoption in businesses

3.1 Relevant facts and figures

As stated, this section's aim is to inspect how AI is generally perceived within the management and executive segment of most relevant businesses: the 2019 New Vantage Partners (NVP) Survey[14] on AI and Big Data provides useful statistic and findings that are very helpful to depict a general outline of the current situation. It is a particularly interesting survey because it represents nearly 65 "Fortune 1000" companies or leading industry firms.

Furthermore, there have been an evident increase in the participation of the so called "C-executives"[15], while few years ago those kind a job positions did not even exist: naturally, if technology modifies the nature of many jobs, there will be also the need for new managerial roles within firm's organization. Nevertheless, if we take the example of the CDO[16] role, there is still a consistent scepticism about the possible relevance of such role; in fact, a significant 17.5% of executives consider the CDO either a pointless or transitional role. It is likely that this question will be better addressed in the next years.

Other negative figures include a surprising 77% of respondents that stated how AI and big data adoption within the business processes remains a difficult task for many firms. Additionally, there is a decreasing trend regarding the number of companies that claim to have developed a data-driven structure (only 31%). In particular, the answers given highlighted the fact that technology complexity is not the problem; the real issue is the interaction between people, technology and the change in processes. As will become increasingly evident proceeding through next sections, the (sometimes) complicated humans-technology relationship is probably the most recurring and relevant theme of this thesis.

The negative statistics I have just reported are arguably offset by the positive finding that NVP's survey displays. Many large companies are taking the opportunity to deploy AI-related technologies in their businesses. The 21% percent of firms examined have invested more than $500 million in AI/Big Data activities, an important result compared to the 12.7% of 2018.

[14] New Vantage Partners (NVP), *"Big Data and AI Executive Survey 2019. Data and Innovation: Leveraging Big Data and AI to Accelerate Business Transformation", 2019.*
[15] Chief Data, Analytics or Information Officers
[16] Chief Data Officer

Another interesting report from McKinsey Global Institute[17] estimates that leading tech firms spent between 20 and 30 billion dollars on AI during 2016, with respectively 90% of this amount devoted to R&D projects and 10% spent on acquisitions. Mergers and Acquisitions (M&A) are becoming essential strategies to secure expertise and proprietary knowledge. Giant retailers are also significantly active in the adoption of AI as the next section will demonstrate.

From a strategic perspective, what are the main motivation behind growing investments in AI technologies? Understandably, only 5% of executives stated that AI adoption was mainly related to a cost minimization strategy. Although overall cost reduction is surely a positive outcome, a business strategy that is focused purely on this aspect will probably not last long. Less experienced companies are usually those which focus more on cost minimization. On the other hand, 91.7% firms adopted AI in order to pursue greater agility and competitivity; in fact, 75% of executives declared to fear the competition from data-driven firms that will try to disrupt the market.

The threat represented by new entrants depends particularly on the underlying technologies that characterize specific industries. Thus, it is necessary to make a distinction between hardware-based vs. software-based technologies: intuitively, hardware-based AI technologies require both more time and more investments, while software-based applications are generally easier to implement at least from an economic perspective. If, for example, pure algorithms and data represent the main ground for competition in a certain sector, the threat of new entrants will be a central aspect to consider.

Finally, another important question is: which types of AI-related technologies are more prominently considered by companies? MGI's paper reports that Machine Learning was the principal subject of most investments, both internally and externally. Moreover, the great majority of executives (90%) stated that significant investments were made also on Cloud Computing. Another important result is the increase in the percentage of firms (from 68.9% in 2017 to an impressive 90.5% in 2019) that invested in Machine Learning approaches.

The applications of such technologies range from manufacturing operations (predictive maintenance quality testing, yield enhancement) and business processes (assessment of R&D projects, supply chain management, business support activities) to customers service functions (marketing and sales).

[17] McKinsey Global Institute (MGI), *"Artificial Intelligence: the next digital frontier?",* independent discussion paper, June 2017.

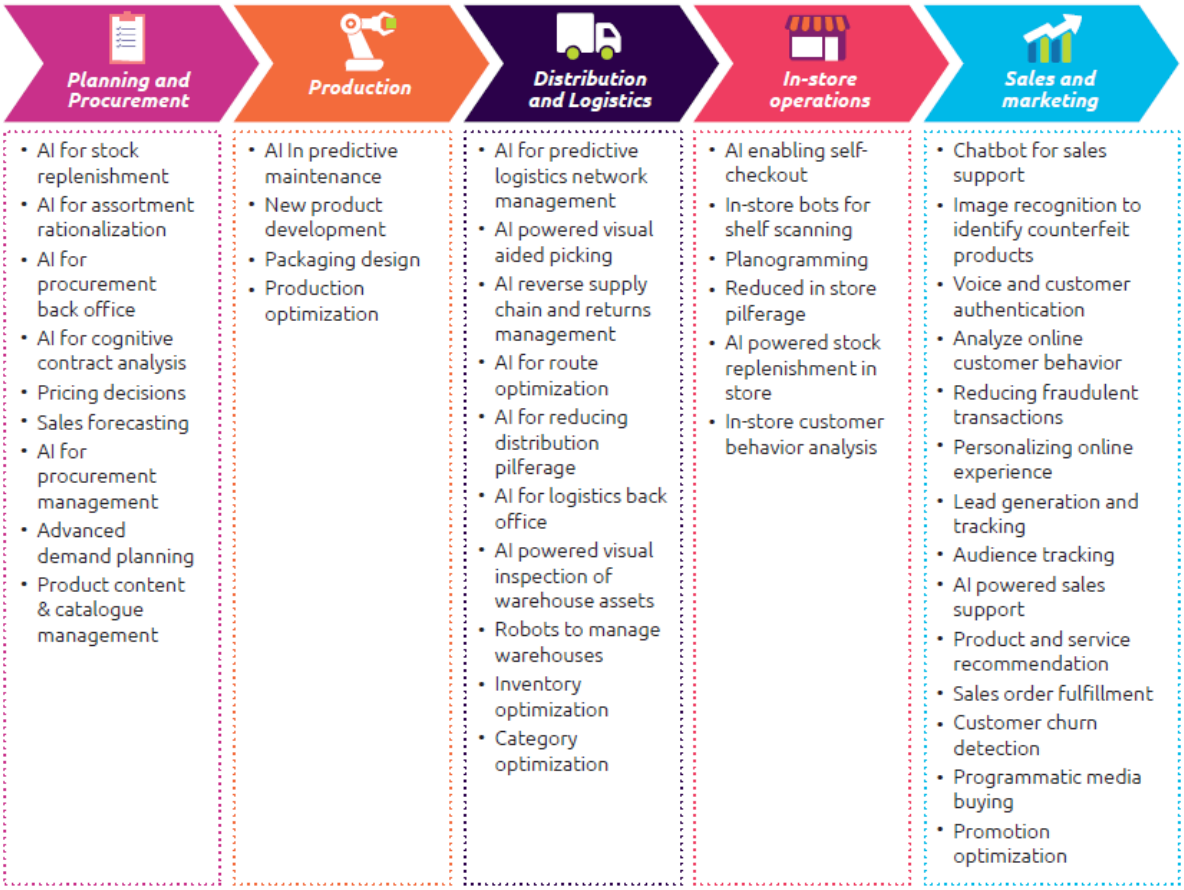
Section 3.2 AI employment in the retail industry

The American retail sector is one the most fertile segment for the possible applications of AI. A report issued by Capgemini [18] indicates that a significant number (28%) of retailers are currently deployed AI across their value chain segments. In particular, there is one major finding: 71% of retailers stated that AI technologies are fostering the development of new jobs, whilst the 75% of the companies surveyed affirmed that has not eliminated any kind of job in their business thus far. For the moment, this is an important response to the social debate regarding the fear of future job losses due to an extensive adoption of AI and automation practices.

Even in this case, AI finds most of its employment in the sales/marketing segment of the value chain. The reason is that AI can effectively improve sales and reduce customers' complaints. To provide an example, leading retailers like Tesco and Walmart have substantially invested in machine learning algorithms and graphical processing units (GPUs) respectively. Stich Fix, the company that will be protagonist of the business case analysis in the next chapter, is one of the few current examples of a firm that deploys AI, data science and algorithms across all the main segments of its value chain.

[18] Capgemini Research Institute, "*Building the retail superstar: How unleashing AI across functions offers a multi-billion dollar opportunity",* 2018.

Figure 11. AI use cases across the retail value chain



Source: Capgemini Research Institute analysis

This table highlights the most relevant possibilities for AI deployment in different segments of a retailer's value chain. The business case analysis of Stitch Fix will provide a practical example of AI integration regarding especially production and distribution/logistics: new product development and optimization (the "genetic" algorithms section of the case study) will be discussed, as well as the processes related to inventory/warehouse/shipment optimization. About in-store operations, the previously described Amazon Go supermarket represent a valid example of self-check-out enabled by AI. Then, the same techniques employed for the planning and procurement segment can be also applied to the sales and marketing division.

4. THE POSSIBLE SOCIAL IMPACT OF NEW ADVANCED TECHNOLOGIES

4.1 The development of the Fourth Industrial Revolution

After having analysed the broad landscape of activities to which AI is currently applied, it is reasonable to imagine an increasing development and adoption of AI-related technologies in such sectors of the global economy, and probably even in those segments that are still reluctant to embrace automation (education for example).

Naturally, there are great socio-politic and economic differences among world's countries that in some cases will carry relevant implications for the future employment of AI. This thesis has described different types of technologies and the improvement they have brought/could bring to certain job performances and more broadly to firms, national economies, people.

Nevertheless, in these last years the most advanced economies of the world are rapidly transiting from the "digital revolution" (which started with the invention of Internet and computers) to the recently identified "Fourth Industrial Revolution" (that encompasses latest advances in AI, IoT, robotics, cybernetics, etc.). This definition was first coined by Professor Klaus Schwab[19], as it was the title of his own book. The German Professor delineates the major technologies that are characterizing this revolution and debates its actual and possible consequences on all the components of modern society: individuals, firms, institutions, governments.

In particular, he draws the attention of institutional actors (governments, policymakers) that have the responsibility of promulgating innovation whilst limiting the socio-economic drawbacks. About this rapidly changing scenario, Schwab states that: *"The changes are so profound that, from the perspective of human history, there has never been a time of greater promise or potential peril. My concern, however, is that decision-makers are too often caught in traditional, linear (and non-disruptive) thinking or too absorbed by immediate concerns to think strategically about the forces of disruption and innovation shaping our future."*

[19] Professor Klaus Schwab was born in Ravensburg, Germany in 1938. He is the Founder and Executive Chairman of the World Economic Forum, the International Organization for Public-Private Cooperation. In 2016 he published his book "The Fourth Industrial Revolution".

Always according to Schwab, citizens should not be mere spectators of such transition but conversely they will have to join decision-makers for *"together shape a future that works for all by putting people first, empowering them and constantly reminding ourselves that all of these new technologies are first and foremost tools made by people for people."*

Personally, I strongly support such vision, that clearly does not aim at concealing the social dilemma of progressive automation for the mere purpose of scientific progress and/or economic profits, as some people may argue. Instead, these statements highlight (without excessive and futile alarmism) the possible challenges in order to empower particularly those segments of the workforce that are more exposed to future job disruption. Workers and unions should not try to fight against AI because they are afraid of job loss, but they should rather seek to undertake a "re-skilling" process to exploit effectively such new technologies. Naturally, the study and development of such processes must be carried out by institutions and governments.

The powerful concept described by Prof. Schwab is similarly reinterpreted by Erik Brynjolfsson[20], director of MIT Initiative on the Digital Economy: *"I think it is more likely than not that we will use this power to make the world a better place. For instance, we can virtually eliminate global poverty, massively reduce disease and provide better education to almost everyone on the planet. That said, AI and ML [machine learning] can also be used to increasingly concentrate wealth and power, leaving many people behind, and to create even more horrifying weapons. Neither outcome is inevitable, so the right question is not 'What will happen?' but 'What will we choose to do?' We need to work aggressively to make sure technology matches our values. This can and must be done at all levels, from government, to business, to academia, and to individual choices."*

Brynjolfsson emphasizes the need of a collective collaboration between all the element of a society, hinting that both ethical, legal and regulatory questions should be addressed effectively to foster sound innovation practices and to protect individuals' rights.

[20] Erik Brynjolfsson is the director of the MIT Initiative on the Digital Economy and author of "Machine, Platform, Crowd: Harnessing Our Digital Future,". He was one of the influential experts selected by Pew Research Center to answer the question: "By 2030, do you think it is most likely that advancing AI and related technology systems will enhance human capacities and empower them? That is, most of the time, will most people be better off than they are today? Or is it most likely that advancing AI and related technology systems will lessen human autonomy and agency to such an extent that most people will not be better off than the way things are today?". This question was the central theme of the paper *"Artificial Intelligence and the Future of Humans" by Pew Research Center, December, 2018.*

Thinking from another perspective, I believe that technology will probably reshape our human values (hopefully for the better) rather than simply match it. This personal belief is strictly linked with the employment of AI in the education system as described in Chapter 1: if standard exercises like algebra equations and spelling correction will be automated, other "higher order" activities (e.g. creative mathematics[21] and original writing) will consequently obtain more value.

Since today's students will most likely face a continuingly changing labour market, it is of pivotal importance that they develop critical and creative thinking characterised by flexibility and agility. It is probable that the so-called STEM[22] subjects will become more valuable for the students as automation technologies will be increasingly employed in different businesses.

The best long-term hope is that AI adoption and automation will somehow help us all to rediscover and redefine true human values.

[21] https://creativemaths.net/about-creative-maths/
[22] Science, Technology, Engineering, Mathematics.

4.2 Actual concerns and possible solutions

AI and the future of humans: Experts express concerns and suggest solutions

CONCERNS		
	Human agency: Individuals are experiencing a loss of control over their lives	Decision-making on key aspects of digital life is automatically ceded to code-driven, "black box" tools. People lack input and do not learn the context about how the tools work. They sacrifice independence, privacy and power over choice; they have no control over these processes. This effect will deepen as automated systems become more prevalent and complex.
	Data abuse: Data use and surveillance in complex systems is designed for profit or for exercising power	Most AI tools are and will be in the hands of companies striving for profits or governments striving for power. Values and ethics are often not baked into the digital systems making people's decisions for them. These systems are globally networked and not easy to regulate or rein in.
	Job loss: The AI takeover of jobs will widen economic divides, leading to social upheaval	The efficiencies and other economic advantages of code-based machine intelligence will continue to disrupt all aspects of human work. While some expect new jobs will emerge, others worry about massive job losses, widening economic divides and social upheavals, including populist uprisings.
	Dependence lock-in: Reduction of individuals' cognitive, social and survival skills	Many see AI as augmenting human capacities but some predict the opposite - that people's deepening dependence on machine-driven networks will erode their abilities to think for themselves, take action independent of automated systems and interact effectively with others.
	Mayhem: Autonomous weapons, cybercrime and weaponized information	Some predict further erosion of traditional sociopolitical structures and the possibility of great loss of lives due to accelerated growth of autonomous military applications and the use of weaponized information, lies and propaganda to dangerously destabilize human groups. Some also fear cybercriminals' reach into economic systems.

Pew Research Center, "Artificial Intelligence and the Future of Humans". December, 2018.

This figure briefly highlights some of the problematic aspects which may arise a result of an extensive employment of AI over the next years. Unfortunately, the case of data abuse has already become a major issue nowadays, but the hope is that AI will also be exploited by supervisory authorities in order to protect users' sensitive information and guarantee a secure environment.

The same reasoning would apply for the argument on human agency. Regarding the theme of job loss, an eventual growth of economic inequality between different nations, along with a rise in the percentage of wealth held by already the world's richest people, could be the real danger. Again, as repeatedly stressed in this chapter, two main factors are essential: a strong and valid cooperation

between all members of society and the right objectives than institutions, governments and leader companies should pursue.

It is true that technology has already modified in various aspects the way we interact with others and probably even with ourselves. The dependence lock-in is a possible outcome that can derive from an inadequate use of AI, but intelligent systems can theoretically offer us many opportunities to better express our abilities and passions. Technology has evolved so drastically in the last decades that making predictions about future developments is quite hazardous.

Finally, the mayhem scenario is closer to sci-fi than the actual reality, but there are still serious aspects to consider: the large amount of misleading and untruthful contents available on the web surely represents a challenge; the same is valid for the threat of cybercriminals.

This figure suggests three possible approaches in order to foster a healthy integration of AI in both business and social contexts. Surely there is the necessity to develop a more effective collaboration between firms and their stakeholders to ensure a progressive innovation that does not discriminate certain categories of workers, social classes or ethnic groups. In order to so, there will be an increasing need for new regulations and policies to preserve our social and ethical values.

5. STITCH FIX, INC. BUSINESS CASE ANALYSIS

5.1 Presentation of the case

This chapter presents the business case analysis of Stitch Fix, Inc. I selected this company for two main reasons: first of all, the core business of Stitch Fix is heavily concentrated around data science, innovative AI techniques and proprietary algorithms. This characteristic makes it a potentially disruptive firm within the retail industry and one of the first successful (for now) examples of extensive AI adoption along the principal value chain's segments.

The second reason is equally important to explain this choice: as it immediately transpires from Stitch Fix's mission and vision statements, this company is giving a valid demonstration of the positive results that a balanced (and fruitful) human-technology cooperation can provide. Even though technology expertise is the core element which provides a competitive advantage for Stitch Fix, its effectiveness is surely granted by human experts' contribution; such contribution delivers a fundamental component of personalisation that is positively perceived and appreciated by the company's costumers. Stitch Fix promotes a collaborative interaction between technology and humans, and by doing so it also addresses some of the challenges discussed in the previous chapter (the danger of data abuse and loss of decision-making power).

Furthermore, I personally believe that the case of Stitch Fix can represent a managerial inspiration not only for fellow retail firms, but also for companies that operate in different contexts.

The first part of this chapter illustrates accurately the main stages of Stich Fix's business process. Then, there is an analysis of why and how algorithms (both classic and "genetic") are an essential element for the company's mission; the relevance of applied data science (the Data Platform team) is reported as well. Next, the chapter present a brief description of the US apparel market, that is the economic segment where Stitch Fix is included. Finally, I choose to employ two renowned managerial frameworks: the Business Model Canvas and the SWOT analysis; their purpose is to conclude the case analysis with an intuitive strategic overview of the company.

Most of the references selected for this analysis were taken directly from Stitch Fix's website and from official documents released directly by the company (quarterly earnings releases, shareholder letters, corporate governance guidelines, etc..).

5.2 Introduction to Stitch Fix

Stitch Fix is an online personal style service for both men (since 2016) and women founded in 2011 by Katrina Lake, who is also the current CEO. Created with the mission of changing the way people find clothes by blending the human element of personal styling with high-quality clothing and proprietary algorithms, the company became profitable in 2014 (despite having raised only $42.5 million of equity capital since inception) and subsequently filed for an IPO on November 2017. As of January 31st, 2019, Stitch Fix has reported net revenue of $370.3 million, net income of $12.0 million and adjusted EBITDA of $19.2 million, along with a customer base of 3.0 million active clients.

In addition to a solid financial outline, Stitch Fix was also ranked fifth on Fast Company's "The World's most innovative companies 2019" list[23] and first among retail companies, an important recognition highlighted by Fast Company in a concise caption that explains the nomination: "for fixing retail one data point at a time". This sentence outlines a couple of concepts that are crucial for the mission and vision of Stitch Fix, which are represented by the company's official mission statement:

"Stitch Fix is transforming the way people find what they love, one client at a time and one Fix at a time."

The strength of this statement lies in two different points: the word "transforming" that alludes to the innovation culture that is embedded in the company's philosophy, and the recurrent formula "one.. at a time" which refers to a new client-centric concept of retail proposed by Mrs Lake's company. At this point, an instinctive question would be: "What is a Fix?". A Fix is basically the one and only "service" offered by the Californian company: to start using Stitch Fix, clients must complete a personal style profile questionnaire where they provide preferences on style, fit, size, and price. Clients can then select the desired frequency for this service, choosing for either auto-ship at a specific cadence or opting for the service on-demand as needed. Stitch Fix then sends each client a "fix", which is a box containing a personalized selection of apparel, shoes and accessories. Each fix contains five items, which the client can try on undisturbed at home. Within 3 days, he/she then selects which items to keep, and returns the others in a prepaid bag. Every time a fix is purchased, there is a styling fee cost of $20 attached to the box, which eventually can be credited towards merchandise purchased. Customers who wish to keep all the five items get a 25% discount on the order.

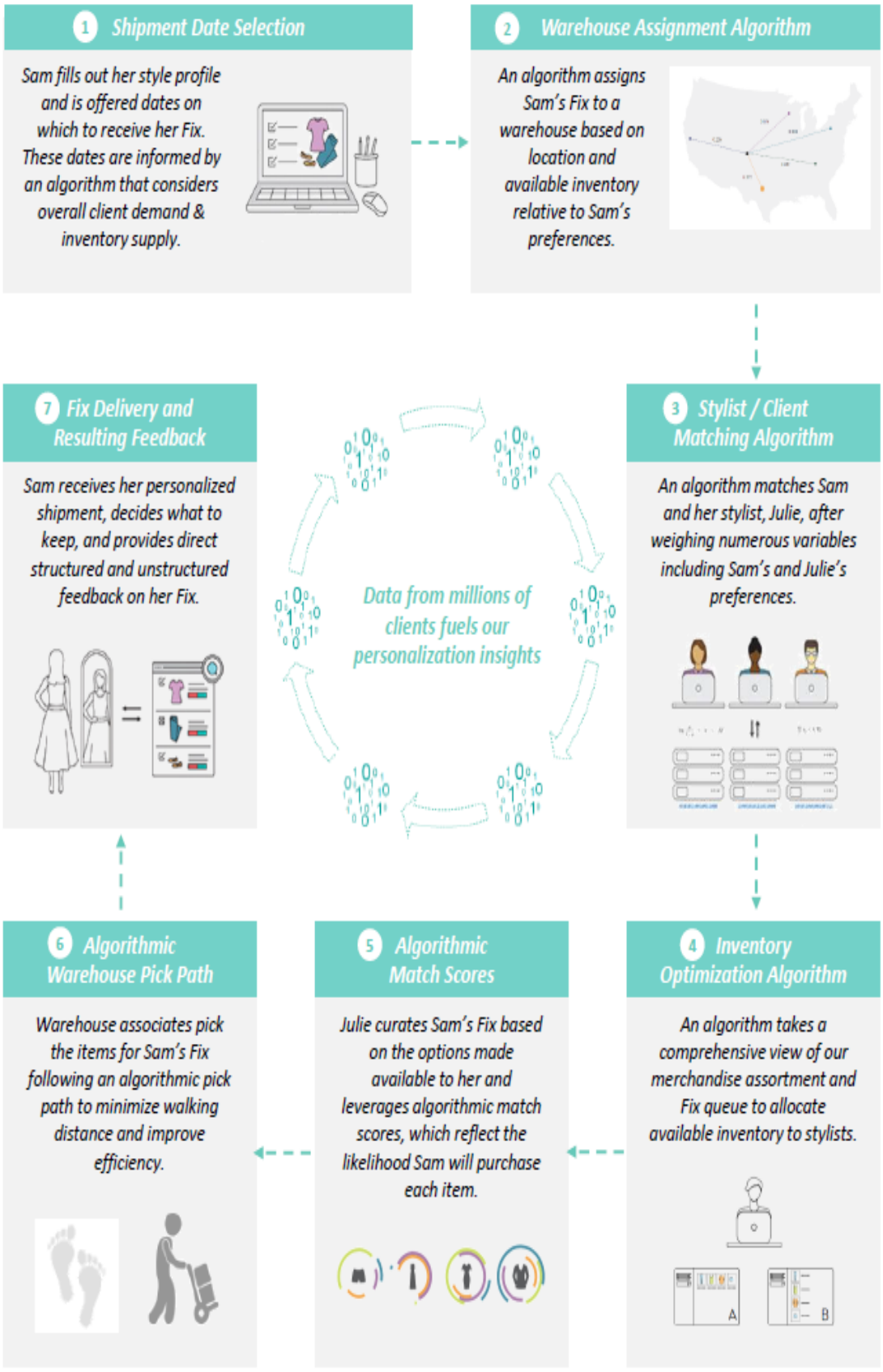
[23] https://www.fastcompany.com/most-innovative-companies/2019/sectors/retail

Alternatively, clients may purchase an annual Style Pass, which offers unlimited styling for the year for a $49 fee that is also credited towards items purchased. Moreover, another valuable option is the Extras feature that allows clients to select items such as socks, bras, underwear and other intimates that are then added to the five items their stylist selects for their Fix.

While working as a retail consultant, Katrina Lake was inspired by the level of services in recent years and saw the opportunity to combine the data science with the art of personal styling to develop a truly personalized shopping experience at scale. She applied to Harvard Business School with the intention of starting and developing a business while studying there and shipped the first Fixes out of her apartment in Cambridge, Massachusetts.

Stitch Fix business model enables the broad concept of data science, applied not only in recommendation systems, but also in human computation, resource management, inventory management, algorithmic fashion design and many other areas. An important core value is that Experimentation and algorithm development are deeply entrenched in every activity performed by Stitch Fix.

Clients are asked to complete a profile upon signup that provides experts at Stitch Fix with the most useful data obtained with the least client effort. In addition to the rich feedback data provided by clients, Stitch Fix also receives an important amount of upfront data on both clothing and clients. Buyers and designers capture dimension and style details, while clients fill out a profile upon signup that's calibrated to extrapolate the most useful data with the least client effort.


1 Shipment Date Selection
Sam fills out her style profile and is offered dates on which to receive her Fix. These dates are informed by an algorithm that considers overall client demand & inventory supply.
2 Warehouse Assignment Algorithm
An algorithm assigns Sam's Fix to a warehouse based on location and available inventory relative to Sam's preferences.
3 Stylist / Client Matching Algorithm
An algorithm matches Sam and her stylist, Julie, after weighing numerous variables including Sam's and Julie's preferences.
4 Inventory Optimization Algorithm
An algorithm takes a comprehensive view of our merchandise assortment and Fix queue to allocate available inventory to stylists.
A
B
5 Algorithmic Match Scores
Julie curates Sam's Fix based on the options made available to her and leverages algorithmic match scores, which reflect the likelihood Sam will purchase each item.
6 Algorithmic Warehouse Pick Path
Warehouse associates pick the items for Sam's Fix following an algorithmic pick path to minimize walking distance and improve efficiency.
7 Fix Delivery and Resulting Feedback
Sam receives her personalized shipment, decides what to keep, and provides direct structured and unstructured feedback on her Fix.
Data from millions of clients fuels our personalization insights

5.3 How Stitch Fix works

5.3.1 First step: data collection

When a costumer first signs up for the service, he/she fills out a Style Profile questionnaire which can be updated anytime. On average, each client directly provides over 90 meaningful data points through his/her style profile, including detailed style, size, fit and price preferences, as well as unique inputs such as how often he/she dresses for certain occasions or which parts of his/her body the client likes to exhibit. Over time, through their feedback on Fixes they receive, clients share additional information about their preferences as well as detailed data about both the merchandise purchased and returned. Stitch Fix has stated that on average over 85% of shipments have resulted in direct client feedback. This feedback loop drives important network effects, as data provided directly by the client can expand personalization capabilities for the specific client and also contributes to a better service for future clients.

In 2018, the San Francisco-based company introduced Style Shuffle, an interactive mobile and web-based game in which participants can rate an assortment of Stitch Fix merchandise, providing additional information to strengthen the existing database of client tastes and style preferences. Often perceived as a sort of "Tinder for clothes", it was designed by Christopher Moody, actual manager of AI instrument at Stitch Fix, who joined the company in January 2015. Moody was disappointed that the company only received feedback from customers on the five items shipped in each box. This frustration helped him developing this particular feature that became available on Stitch Fix's iOS app in March 2017.

Style Shuffle has proven to be truly addictive: It not only trains the company's algorithm to understand holistically a client's personal style, but it also draws customers back to the app and interests them in Stitch Fix's inventory. More than 75% of Stitch Fix's 2.9 million customers have used it, providing the company with more than a billion ratings. Style Shuffle has vastly improved the company's ability to personalize its offerings and has boosted Fix requests.

Stitch Fix has a robust belief that its proprietary merchandise data set is differentiated from other retailers, as each Stock Keeping Unit (SKU) is programmed with many information attributes that allow algorithms to make better recommendations for each client. The information stored for each SKU includes:

• basic data, such as size, brand, colour, pattern, silhouette and material;

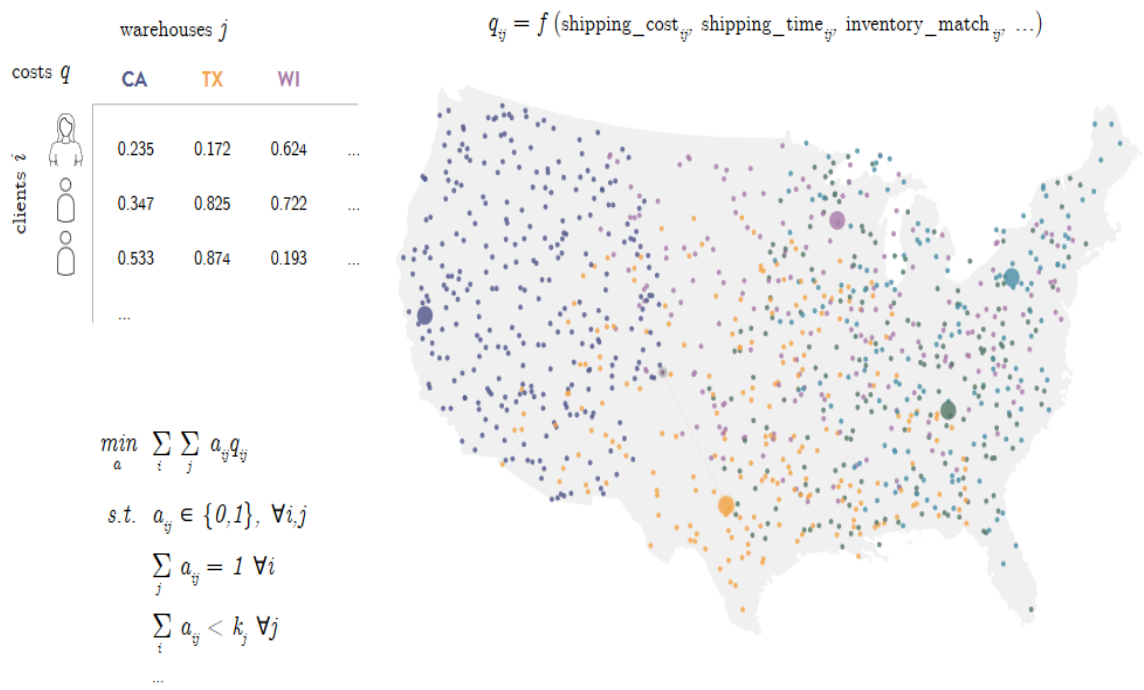
• item measurements, such as length, width, diameter of sleeve opening and distance from collar to first button;

• nuanced descriptors, such as how appropriate the piece is for a client that prefers preppy clothing or whether it is appropriate for a formal event; and

• client feedback, such as how the item fit a 5’10” client or how popular the piece is with young mothers.

After the client submits his/her Style Profile, a delivery is scheduled according to an algorithm that is used to populate a calendar from which the client selects a delivery date.

At this point, the shipment request is sorted out by an algorithm function that associates it to a warehouse. Such algorithm determines a cost function for each warehouse considering its location with respect to the client. It also considers the correlation between the inventories in different warehouses and the client's needs. This sequence of cost calculations is performed for each client in order to elaborate a cost matrix. Then, the assignment of clients to warehouses is translated into a binary optimization problem, with the global optimum that comprises the specific client’s warehouse assignment.



5.3.2 The role of Algorithms within the company

Stich Fix employs machines that operate a variety of algorithms to produce rank-ordered lists of the inventory. A filtering phase disregards styles from consideration that the client has received in a previous shipment or that have characteristics which the client has demanded to avoid. For each of the remaining styles, the machines try to calculate the relative probability that a specific client will prefer that certain style. This problem resembles a classic collaborative filtering problem: given different feedbacks on different styles, there will be gaps in the matrix to be fulfilled in order to predict the outcome of delivering a style to a client who did not receive it before. Stitch Fix utilizes some standard collaborative filtering algorithms (example: “those who have liked what you have liked, have also liked..”, a formula that is prominently offered by Netflix).

Differently from the majority of collaborative filtering problems, in the case of Stitch Fix, clients provide a lot of explicit data, both from personal descriptions and from clothing qualities. This procedure helps to overcome the “cold start” problem that frequently happens in face-to-face situations (when initially clients have troubles in expressing their preferences) and also permits greater precision if there are existing algorithms that consider this data. An approach similar to the one described is

mixed-effects modelling, which is particularly useful considering the nature of this problem: it allows to learn and trace clients' preferences over time, both individually and as a whole. Other than the many explicit descriptive features presented, there are some curiously relevant latent features of both clients and styles that can be extrapolated from other data (structured and/or unstructured) and used to improve overall performance.

Extending this problem further than classical collaborative filtering, experts also have many photographic and textual data to consider: those data include inventory style photos, Pinterest boards, and the vast amount of written feedback and request notes received from clients. Sometimes, it can be difficult to describe personal style preferences in words, but many people can recognize a favourite style when looking directly at it. Thus, Stitch Fitch deploys machines that can detect photos of clothing that customers like (e.g. from Pinterest), and subsequently search for similar items in the inventory.

Furthermore, trained neural networks can be used to derive vector descriptions of selected images, and then compute a cosine similarity between these vectors and pre-computed vectors for each item in the inventory. Natural language processing is used to rank items based on the client's request note and textual feedback from other clients about the same item.

All these algorithms' scores and many others are taken into account when ordering and presenting options for the human expert stylist to consider.

5.3.3 The matchmaking method

After the machine ranking is complete, the shipment request is transmitted to a human stylist. Naturally, people are more heterogeneous than machines. While machines are identical to each other when sharing the same set of attributes, human stylists instead are going to work better with some clients than others. Again, Stitch Fix avails itself of powerful and proprietary algorithms to optimize this match. In order to perform this task, the first step implies calculating a match score between each available stylist and each client who has currently purchased an order.

The match score is a complex function that involves two elements: the previous relationship between client and stylist (if any), and the similarities between the client's stated/latent style preferences and those of the stylist. Afterward, the stylist needs to solve an assignment optimization problem that is comparable to the warehouse assignment problem previously described. The difference is that it needs

only to consider those clients awaiting shipments, and that the optimization problem has to be solved much more frequently to deal with the varying sizes of stylists' queues as they work.

If machines are surely great for tasks involving complex calculations, there are other challenges that necessitate a proper social interaction, improvisation and the ability to create an enduring relationship with the clients. These tasks are in the control of Stitch Fix's human staff. The company has nearly 3,900 stylists who work remotely part-time and are paid hourly. Stylists are empowered with custom styling tools that leverage the database and algorithms. Another important aspect for Stitch Fix's credibility is that stylists are not compensated based on commission to have the flexibility to suggest less expensive items. Stylists deliver the critical human element required to build one-to-one relationships, make better recommendations, and provide a personalized experience. They provide the creativity, empathy, and context to deliver unique Fixes at scale.

To begin styling a shipment, a stylist picks up a task in a customized interface designed to help her quickly and deeply understand the client. The human computation team at Stitch Fix does a lot of testing with variations on this interface in order to understand better how stylists make decisions. This additional knowledge can be useful under many aspects: to improve existing algorithmic styling, to improve stylist training procedures and to continually improve the interface that stylists use to curate boxes. The process of selecting the right items for each client is a simple task only in appearance. Instead, it involves many components.

Each attribute that describes a piece of merchandise can be represented as data and reunited to each client's unique preferences. For example, the way a certain jacket fits tightly on the shoulders and displays the upper arms may be valued positively by some clients while being an undesirable quality to others. Attributes such as colour, fit, style, material, pattern, silhouette, brand, price, trendiness, etc... can each be similarly quantified for the value they provide to each client. Machines are great at finding and applying these relationships. They can even quantify interactions between latent attributes, those ignored by clients themselves, capturing the value provided by hidden relationships.

Machines perform these tasks by computing billions of calculations on structured historical data that capture the interactions between each client and each piece of merchandise. This might include distance or similarity calculations, mixed effect models, matrix factorization, principal component analysis (PCA), logistic regression, or different statistical-learning/machine-learning techniques. The output from machine processing is a set of values representing the relevancy between the client and each piece of merchandise. These scores capture all the relationships inherent to the data, representing

the aggregate knowledge amassed from vast amounts of client-merchandise interactions, and applied to the personal preferences of each client.

Given their distinct abilities contraposed to that of machines, stylists take on a very different set of tasks within the styling process. First, they exploit additional information that only they, as humans, have access to. Unstructured data that comes in the form of images, videos, and free-form text can be used to further elaborate the relevancy between the client and the merchandise.

Clearly, material expressions of client preferences are still notoriously difficult to process by machines. Only a human stylist can interpret a free-form requests such as “I need a dress for an upcoming trip” or understand specific preferences from a client’s Pinterest board.

Next, the stylist performs the task of curation, where concepts from the individual items are harmonized to create a cohesive set that collectively represent better relevance. Ultimately, the stylist finalizes the selections from the inventory list and writes a personal note suggesting how the client might accessorize the items for a particular occasion and/or how they can pair them with other clothing in their closet. The aim of this procedure is to foster an enduring relationship providing transparency and engendering trust. This last step completes the styling procedure, and the shipment is now ready to be processed.

There is a clear business ideology that already transpires from the steps that constitute this first part of a fix’s chain. An ideology that links this specific analysis of Stitch Fix with the general AI applications’ framework discussed in the first part of this dissertation: cooperation between humans and machines results in a set of merchandise more relevant than either machine or human could have achieved alone. Working together, their individual efforts combine to produce a fusion that exhausts all processing and all data. Over time, their contributions are even reinforcing as they provide each other with useful feedback, validating hypothesis in some cases and revealing certain biases in others.

This alliance between Humans (stylists) and Machines (algorithms) accurately represents the “Art&Science” concept that is pivotal in the business vision of Stitch Fix.

5.3.4 A brief recap of the process

To recap the process of filling a single shipment request: a client creates a Style Profile and requests a shipment. The order is then matched to a warehouse: Subsequently, styling algorithms and human stylists work together to select styles. Finally, the stylist writes a note, the shipment is delivered, and the client keeps what he/she likes, returns the rest, and provides the company with feedbacks on each item. But this is just one shipment. Zooming out and considering a global perspective, two other aspects of Stitch Fix's business become clear:

1. The inventory must be replenished continually by buying and/or designing new clothing for the clients.
2. Clients' needs must be anticipated in order to constantly have enough of the right resources in place at the right times.

Considering the business model of Stitch Fix, it is clear how a flawed inventory management or a mistaken anticipation of clients' needs could potentially lead to both increasing operational costs and decreasing revenues, thus undermining all the other business pillars of the company. In order to tackle these two delicate challenges, Stitch Fix developed the concept of state machines and improved signifcantly the inventory management framework.

State machines are suited for a deeper understanding of different customer needs with the aim to anticipate them, while inventory management has improved thanks to new inventory optimization algorithm and the development of Stitch Fix's exclusive line of clothing.

5.3.5 The analysis of clients' states

One of the ways in which this needs-anticipation problem can be interpreted is to consider the "state" of each client at each point in time. Whether they are new clients, regular ones, male/female, married/not married, depending on their state they will likely have difference shipment cadences, different preferences for email contact, and so on. Keeping track of every touch point with each client (every item, every piece of feedback, every referral, every email) is essential to understand clients'

states and their needs when in those different states. Then, changes in state can be detected and possible triggers can be considered.

The aim of this process is to gather useful insights that will help keeping clients happier. Once these states and clients' transition between them are defined and understood, the consequent development of state transition matrices and Markov chain models is a natural way that allows experts at Stitch Fix to study results at a system-level.

One of the many uses of these Markov chain models is to anticipate future demand, which is important because inventory is typically bought months before it arrives at the warehouses. Another fundamental aspect is to have the right number of resources and human stylists available at the right time.

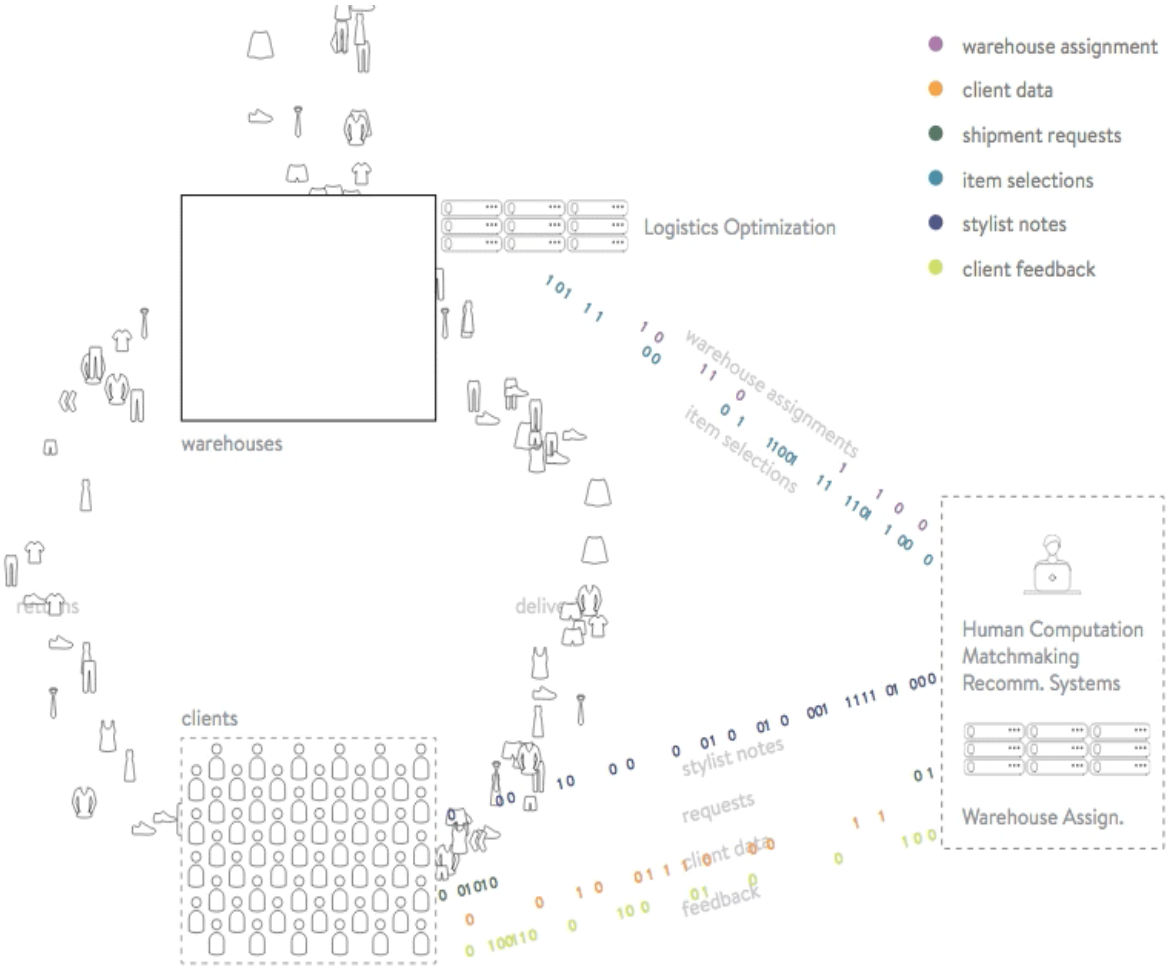
5.3.6 Inventory Management

Inventory reduction through customer demand must ultimately be offset by purchases of new inventory. One of the challenges is in getting the timing of purchases right, so that it is possible to maintain adequate inventory availability for stylists while minimizing the sum of ordering costs, the operation costs and opportunity costs of capital.

Meeting future demand is just one of inventory management challenges: an appropriate allocation of inventory to different warehouses is essential, as well as occasional donation of old inventory to make room for new styles. Even in this phase, algorithms can help optimizing these processes. There are three typical questions that inventory management at Stitch Fix must address: How much of what styles to purchase? Which items should go to which warehouse? What inventory should be donated when? These questions are answered by using a model of the system dynamics, fitting it to historical data and using it for robust optimization given measured uncertainties in predictions.

In the second quarter of 2019, Stitch Fix launched a new inventory optimization algorithm aiming to a more effective allocation of inventory across its client universe. Typically, inventory allocation was optimized one client at a time based on which client was first in the "Fix queue". The new algorithm considers the preferences of a broader spectrum of clients in the queue as it decides what inventory should be made available to stylists as they style for each client. In doing so, it ensures stylists have the right inventory to meet each client's style preferences regardless of the client's position in the

styling queue. Early results proved that the algorithm contributed to higher client satisfaction, higher number of items purchased per Fix, and increased average order value.



5.4 Darwinism and Fashion[24]

Volumetric challenges are not the only relevant implications involved with inventory replacement: the company has a clear mission to purchase and develop new clothing in ways that inventory can be continually improved, thus helping stylists to perform a better job and give satisfaction to a broader client base.

Stitch Fix has figured out that the designing of new styles for its exclusive brands provides a great opportunity to tailor new designs for specific client segments that tend to be underserved by other

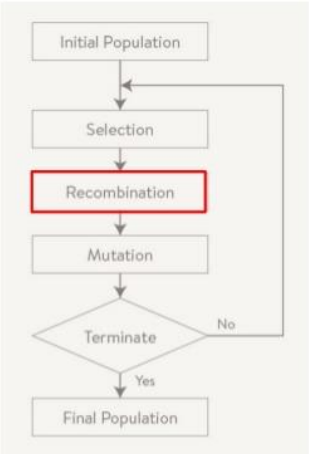
[24] See the Appendix at page 49

brands. Even in this case, the well-established algorithmic approach is used to tackle such a challenge, this time by drawing inspiration from genetic algorithms: recombination and mutation along with a fitness measure, very similar to the mechanism used by mother nature in evolution by natural selection.

This analogy is promptly explained by Eric Colson, a former VP of data science and engineering at Netflix, who joined Stitch Fix in 2012 (and still is its Chief Algorithms Office): “Nature has a selection criterion: It’s called survival. Circumstances that lead to survival, like a giraffe’s long neck, are going to pass on a certain gene,” said Colson. “We notice the same thing occurring in our inventory, any trend emerges this way. It starts spontaneously, like a mutation. The first time you see a cold-shoulder top, it’s weird and different. But if it’s successful, you see more and more styles as people buy more. We have similar selection criteria as Mother Nature, except it’s not survival. It’s customer feedback”.

Colson and his team realized Stitch Fix could have deployed a survival-of-the-fittest blueprint to its inventory in order to create different patterns of blouses, jackets and pants that are able to predict and fulfil trends as customers are demanding them. This strategy has resulted in a line of clothing exclusive for Stitch Fix customers, called Hybrid Design, that was produced in-house using an algorithm that searches through clients’ data to come up with new combinations of clothing traits that previously didn’t exist in Stitch Fix’s inventory.

Example: Evolutionary clothing design



The first step in order to understand this process is to think of each style as a set of attributes ("genes"). Then, a vast set of styles and the client feedback ("fitness") available for each style are evaluated. Afterward, new styles can be developed by recombining attributes from existing styles and possibly mutating them slightly. In theory, the number of possible combinations is extremely large. In the next step, there is a deviation from a classic genetic algorithm: instead of simply selecting based on fitness and then releasing random recombinations and mutations as the next generation of styles, there is a more accurate selection for choosing what can ultimately fit the inventory. First, it is necessary to develop a model of how well a given set of attributes is likely to suit the target clients. This model is then used to highlight a variety of attribute-sets that would virtually have the highest probability to be liked by customers. At this point, the human contribution of designers is fundamental to examine and refine this collection, and ultimately to produce the next generation of styles. These new styles get produced and are made available to the styling algorithm, then on to customers, and the cycle of evolution continues.

5.5 The Data Platform team

The Data Platform team provides the data and compute infrastructure, along with a collection of internal SaaS products, that allow data scientists to effectively and efficiently carry out analysis, write their algorithms, and put them into production. The platform nicely integrates properties like data distribution, parallelization, auto-scaling, failover, etc. This allows the data scientists to concentrate mostly on the science aspect yet still enjoy the benefits of a scalable system.

The data platform engineers focus mainly on building platforms, that is they are not burdened with business logic and requirements for which they don't have the context. That job would be in the domain of the full-stack data scientists. Stitch Fix's Data Platform team enables data scientists to carry algorithm development all the way from concept to production.

The use of data science concepts outside of textbooks has been repressed historically by the lack of data and computing resources to apply them practically and effectively; a final obstacle currently

restricting the concepts to mere theory has been people and culture (organizations are notoriously difficult to change).

However, Stitch Fix seems to be relatively free of such inhibitions. Perhaps this freedom has contributed to foster an environment where data scientists can successfully apply their skills and knowledge. Another fundamental characteristic is that engineers at Stitch Fix do not have to develop and maintain an ecommerce site, since clients delegate the shopping task directly to the company. This allows a more effective application of engineering resources towards internal applications, resulting in polished and elegant internal applications, which can be considered a rarity for most ecommerce companies.

From there, Stitch Fix firmly believes that curiosity, creativity and the desire to have an impact will dictate the way for achieving great results in the future.

5.6 The U.S. Apparel, Footwear and Accessories Market

Stitch Fix is trying to stand out in the massive U.S apparel, shoes and accessories market. Euromonitor, a consumer market research company, estimated that the U.S. apparel, footwear and accessories market was $342 billion in calendar 2017. Furthermore, this enormous sector of U.S economy is expected to grow to $406 billion by 2022, entailing a compound annual growth rate (CAGR) of 3.5%. Apart from global estimates about this huge market, Euromonitor provided also two estimates that are more related to the specific context in which Stitch Fix operates: eCommerce portion of the U.S. apparel, footwear and accessories market was $70 billion in 2017, and it is expected to reach $133 billion by 2022, with a CAGR of 13,8%. These estimates depict an expansion of eCommerce penetration of the U.S. apparel, footwear and accessories market from 20.4% of $342 billion in 2017 to 32.7% of $406 billion in 2022.

Historically, brick-and-mortar retailers have been the primary source of apparel, shoes and accessories sales in the United States. Over time, brick-and-mortar retail has changed and the era of salespersons who know each customer on a personal level has passed. Stitch Fix believes in the fact that many of today's consumers view the traditional retail experience as impersonal, time-consuming and inconvenient. These negative attributes may represent the cause that has led to financial difficulties, bankruptcies and store closures for many major department stores, specialty retailers and retail chains.

A fact that should not be a surprise, since the first wave of eCommerce companies has emerged prioritizing low price and fast delivery. Those companies based their businesses in a transaction-focused model that is well suited for commoditized products and when consumers already know what they want.

However, it is likely that many eCommerce companies often fall short when consumers do not have a specific idea of what they want, assuming price and delivery speed are not the primary decision drivers. There is an overwhelming selection of apparel, shoes and accessories available to consumers online, and searches and filters are defective tools when it comes to finding items that fit personal style, figure and occasion. Most of eCommerce companies also lack the critical personal touchpoints necessary to help consumers find what they like, thus further depersonalizing the shopping experience.

For example, Macy's, one of the largest department stores in the United States, announced in August 2016 its intent to close approximately 100, or 11%, of its stores and Michael Kors, a specialty retailer, announced in May 2017 its intent to close at least 100, or 12%, of its stores. The struggles of traditional retailers are also reflected in broader market data.

According to the U.S. Census Bureau, average monthly department store sales declined $6.4 billion, or 33%, from calendar 2000 to calendar 2016

Stitch Fix's clear advantage over traditional retailers is the transparency it has with customer behaviour through every part of the purchase path. Macy's, for instance, only knows what a customer ends up purchasing and whether or not they end up returning it. Some retailers are taking it a step further, using RFID technology to track data around what is going into the fitting room and not being purchased. But Stitch Fix can identify what a customer is in the market for, what they purchase, what they don't keep and why.

The data set of Stitch Fix has three potentially powerful characteristics:

- the majority of client data is provided directly and explicitly by the client, rather than inferred, scraped or obtained from other sources;
- clients are motivated to share relevant personal data, both at initial signup and over time as they use Stitch Fix, because they trust it will improve their Fixes;
- merchandise data gathered by Stitch Fix tracks dimensions that enable the company to predict purchase behaviour and deliver more personalized Fixes.

Stitch Fix tries to differentiate its business concept from competitors by establishing a deeper connection with every client, defining itself as a company that listens and takes the time to understand each client as an individual. This is the principal reason for which the central message of Stitch Fix's first integrated brand campaign is "everyone deserves to be seen".

5.7 SWOT Analysis of Stitch Fix

The aim of this section is to further analyse the Stitch Fix case through the development of a SWOT Analysis' framework, which is a strategic methodology that highlights Strength&Weaknesses and Opportunities&Threats of a company, including internal, external, competitive and macro-economic factors. SWOT analysis can provide key insights into these factors that profoundly impact the stability and performance of an organization. This framework is widely adopted by strategy makers of different organization to optimize performance, exploit new opportunities, manage competition, maximize return through the optimization of resources employed, and minimization of various business and policy making risks.

Strengths

The concept of "Strengths" in the SWOT analysis's framework refers to firm's resources and capabilities that it can deploy to design, develop and sustain competitive advantage in the marketplace.

1. The primary strength of Stitch Fix is its ability in the *development of data science* to match the inventory with millions of clients' individualized preferences. Historically, along with proprietary and effective technologies, most innovative companies have become widely successful mainly because they properly exploited the academic concept of "first mover advantage". The first mover is a company that offers its products and promote its brand in a completely new market, thus having the possibility to: exploit economies of scale, control competition anticipating new entrants, setting prices, build a strong brand image. By contrast, first mover companies may face some challenges in forecasting production and planning/estimating costs and investments.
2. *Distribution and Reach*: Stitch Fix Inc has a large number of warehouses in almost every state, supported by a strong distribution network that makes sure that its products are available easily to a large number of customers in a timely manner. Another important strength lies in the

adoption of a new inventory optimization algorithm to more effectively allocate items across the broad client universe.

3. *Social Media*: Stitch Fix Inc has a strong presence on social media with more than millions of followers on the three most famous social media platforms: Facebook, Twitter and Instagram. It has high levels of customer engagement on these platforms along with low customer response time.

Weaknesses

Weaknesses of Stitch Fix can either be absence of strengths or capabilities that are required but the organization currently does not possess. Managers must distinguish if the weakness is present because of lack of strategic planning or as a result of strategic choice.

1. *Reliance on few products:*

The company counts on few products that have a high market share, while most of the products have a low market share. This reliance on a few products makes Stitch Fix Inc vulnerable to external threats if the sales of such products decrease for any reason.

Opportunities

1. *Highlight price-matching*:

Stitch Fix has struggled with price perception in the past and needs to deliver customers the sensation of paying an honest price for the value it offers to them. In 2014, the company experienced a minor scandal when a blogger received a pair of Stitch Fix shorts priced at $68 with a $24.95 price tag from Nordstrom Rack, discounted from the regular $68. Stitch Fix management explained the inconvenient by stating that the clothes were shipped by the supplier and that the incriminated pair slipped past quality control and was originally intended for Nordstrom Rack instead of Stitch Fix. The company further reassured its clients that it does not buy clothes from Nordstrom Rack and mark them up.

However, the story underlined a related problem for Stitch Fix: there have been multiple complaints about the cost of its merchandise. The company recently attempted to resolve such situation by offering a broader set of lower-priced merchandise. It has also promised to deliver an effective price-match in order to prevent its customers from preferring rival companies because of lower prices. Otherwise, Stitch Fix may continue to be a victim of the "showrooming effect": clients try on clothes from the company, but then buy it where else will be more convenient.

2. *Allow for reorders:*

In addition to customers looking for lower-priced items, another reason for clients to prefer shopping in stores like Hudson Bay or Nordstrom could be represented by the scenario where a customer would like to purchase twice (or more) an item of Stitch Fix that he/she adores. Nordstrom, for instance, sells many of the same labels as Stitch Fix, thus a Stitch Fix customer may have no other alternative than going to Nordstrom or searching up online shops to find styles similar to a garment they liked from Stitch Fix.

Currently, there is no possibility to order anything directly from Stitch Fix with the exception of Extras items, which can only be added onto regular orders. While the curated styling service is what makes Stitch Fix unique, the business would probably benefit by allowing customers to order some items directly. A possible starting idea would be to allow customers to re-order clothes/accessories they loved in different similar styles or different colours.

On its website, Stitch Fix could display a feature similar to: "Since you loved that, try this" which would propbably delight shoppers who would otherwise have to visit competitors' websites to find more of what fits their tastes. Creating such an interface should not represent an impossible challenge considering the capabilities of Stitch Fix in terms of data, algorithms and general IT development.

3. *Consider adding physical (brick-and-mortar) stores:*

Plenty of companies and brands were created online and successfully transitioned to the brick-and-mortar world. Bonobos, Warby Parker, and even Amazon have all successfully added physical stores to complement their digital presence, as more firms are realising the strength and consistence of an omnichannel strategy. Founded in 2011, Stitch Fix is still a young growing company which, at the moment, is not planning to open physical stores as it's still trying to implement its online model. Notwithstanding, opening stores might represent a valid hypothesis to consider at Stitch Fix for a future business strategy.

Other digitally native businesses have opted to opening stores because it gives them the possibility to reach a demographic segment that is more hesitant to shop online. Moreover, a physical store improves brand awareness as customers' experiences and feedback represent their own form of advertising. Whereas Amazon is the leading online retailer, for example, it's also used physical formats to sell groceries and curate a unique bookstore experience.

Stitch Fix could deploy its own stores to serve a wide range of strategic objectives. For example, the company could open a store to attract a high-end customer with a unique, personalized experience. Otherwise, it could organise its stores to showcase its exclusive brands, which help separate the

company from its competition. Either way, customers would receive the products faster than they do online, and Stitch Fix might avoid the possibility of losing sales to other brick-and-mortar stores. This strategy would probably carry different risks, but it would also represent a possible way to boost sales and increase customer awareness.

5.8 Business Model Canvas

This section will display another famous strategic tool for management that is extensively used by companies worldwide: the Business Model Canvas[25]. Ideated by Alexander Osterwalder[26] and Yves Pigneur, it is characterized by a template of 9 blocks subdivided into 4 main areas. The purpose of such framework is to deliver a rapid, intuitive and global perspective about a company's business. The 3 upper-right pillars represent the costumers' area. These segments generate the revenue streams block that outlines how the value proposition is purchased by the clients. Then, the 3 upper-left pillars form the operations area: key activities and resources naturally translates into the cost structure pillar that the company must face in order to effectively deliver the value proposition to the appropriate costumer segments.

Starting from the core of the model, namely the *Value Proposition*, it is highlighted how Stitch Fix delivers great value to both costumers (who receive a styling service and purchase items) and brand partners (that sell their goods and have the opportunity of getting useful insights on consumers' tastes). These brands also constitute a *Key Partner* of Stitch Fix, along with VCs that provide funds and influencers who sponsor the company mainly through social media platforms. Social media in fact represent one of the *Channels* through which the firm delivers its vision and brand identity to possible clients. Other channels include Stich Fix's official website, the platform Pinterest, the stylists who work for the company and the old-fashioned Word of Mouth (particularly in the formative years of the company).

Moving on to the right sections of the table, it is evident how Stitch Fix targets a mass market; they started with woman apparel and then expanded to cover all the other mentioned categories. The firm engages with clients (*Customer relationship*) by presenting them a stylist's personal note attached to

[25] http://businessmodelalchemist.com/blog/2005/11/what-is-business-model.html
[26] Osterwalder A., Pigneur Y; Clark T. (2010). "*Business Model Generation: A Handbook For Visionaries, Game Changers, and Challengers*". Strategyzer series. Hoboken, NJ: John Wiley & Sons.

their order. Moreover, it offers the possibility to purchase the annual Style Pass, a subscription feature which offers no-limits styling at $49 for a whole year (such payment is also credited towards items purchased, as the regular $20 payment associated to a single order). As previously mentioned, there is also the possibility of playing with the Style Shuffle game on the mobile app or on the website, which is entertaining for the clients and useful for the company at the same time.

Regarding the left side of the table, in addition to *Key Partners* there are the *Key Resources* exploited by the company: proprietary algorithms, stylists' expertise, brand identity, work culture and data-science approach have all been extensively discussed in the previous sections. *Key Resources* are crucial to develop the *Key Activities*: Stitch Fix offers a personal styling service, but it is also creating original designs in order to sell its own items. *Key Activities* are those that bring the *Value Proposition* to costumers.

Finally, the *Cost Structure* is composed by all the operational and administrative expenses (wages, warehouses and plants maintenance, cloud infrastructure development/maintenance, and obviously the cost of goods sold). Stitch Fix will have the possibility to diminish its expenses if the share of own-produced clothes increases.

Opposed to *Cost Structure* there is the last block of the Business Model Canvas: *Revenue Streams*. In addition to the previously cited subscriptions' fee, Stitch Fix draws revenues from the margin it gets on each item sold. Following the same reasoning made for the *Cost Structure,* the company will increase its profits if it will able to sell a greater portion of its exclusive merchandise.

<table>
<tr>
<td rowspan="2"><u>Key Partners</u>

• Brands

• Venture capitalists

• Influencers</td>
<td><u>Key Activities</u>

• Personal styling service

• Retail

• Original designs</td>
<td rowspan="2">V<u>alue Proposition</u>

To Clients:

• Time-saving and flexible styling service

• Quality and diversity of items

• Free delivery and return

To Brand Partners:

• Powerful growth opportunity

• Insights based on client feedback</td>
<td><u>Customer Relationships</u>

• Stylist’s personal note

• Style pass

• Style shuffle</td>
<td rowspan="2"><u>Customer Segments</u>

All the people (belonging to the categories listed below) who seek a comfortable, convenient and personalized styling service.

• Women

• Men

• Petite

• Plus size

• Maternity</td>
</tr>
<tr>
<td><u>Key Resources</u>

• Proprietary Algorithms

• Stylists

• Data Warehouse

• Technology Work Culture

• Strong Brand</td>
<td><u>Channels</u>

• Website

• Social media

• Pinterest

• Personal stylist

• Word of Mouth</td>
</tr>
<tr>
<td colspan="3"><u>Cost Structure</u>

• Selling, General, Administrative Expenses
• Cloud infrastructure
• Cost of goods sold
• Warehouses management</td>
<td colspan="3"><u>Revenue Streams</u>

• Subscription fee (Style Pass)
• Styling service fee
• Margin on each item sold (average price is $55/item)</td>
</tr>
</table>

7. CONCLUSIONS

Notwithstanding the nature of AI's concept entails a great variety of technical and scientific implications (that are rapidly evolving), the purpose of this thesis was to confer a global overview of such phenomenon with a focus on its role within businesses and societies worldwide. The brief introduction to AI's history, past researches and nomenclature from Section 2 aims to provide a simple but solid basis for a better interpretation of current scenarios as well as future prospects related to these new technologies, which have been outlined in Section 3 and 4.

Considering that AI is establishing itself as one of the most disruptive technologies in the history of mankind, Section 4.2 refers to the socio-cultural aspects of this topic: other than businesses, automation is likely to have a significant impact on our social habits even if there are great uncertainty about the extent and magnitude of such effects. Same reasoning applies for the consequences on the workforce (jobs destruction or job creation?) and other macroeconomic factors (GDP growth, unemployment, inequality).

As regards current AI adoption within firms' business cycle, it should transpire from Section 3 that in most cases automation can enable companies to improve results by limiting errors, increasing speed/quality and generating productivity growth. Despite some scepticism that still flutters around in some contexts, often dictated by insufficient knowledge and/or trust in such advanced instruments, the figures highlighted in Section 3 indicate that there is relevant probability that AI will be progressively integrated in many different industries. Again, the speed of such progression is unpredictable since it depends on many factors (governments, politics, education, geography, socio-economic composition of different countries, etc). Section 3.2 is dedicated to the retail industry because it has demonstrated to be one of the most prominent sectors for the commercial implementation of "intelligent" technologies: a clear example is provided by the subsequent case study of Stich Fix, Inc.

Finally, the business case analysis of Stitch Fix ties together many of the topics discussed in the previous sections. In particular, the business cycle and the vision proposed by the Californian firm emphasize the utmost attention that have been dedicated to the development of an effective data-science culture that is pivotal for the company's current success. Even more essential than the sole data-driven algorithmic approach, is the *synergetic collaboration between* ***humans*** *and* ***technologies***. The sophisticated yet natural slant with which Stitch Fix proposes this combination is likely to be replicated by other firms in the next future, and will reinforce the belief, shared by this thesis that competing together with technology is preferable than competing against it.

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APPENDIX

The purpose of this appendix is to further analyse the concept of genetic algorithms, and how they are applied to create new designs and patterns for Stitch Fix's clothes.

A Brief Introduction to Genetic Algorithms[27]

Genetic algorithms constitute a set of methods suited for solving both constrained and unconstrained optimization problems, inspired by genetics and natural selection. Following the biological evolution theory, each possible solution is conceptualized as having a chromosome composed of genes, where each gene's value is an allele. Similarly, a blouse's chromosome is a vector of attributes corresponding to the dimensions of the search space. Generating a new design can then be decomposed as an evolutionary process searching over a population of possible blouses, through a series of generations.

Each generation evolves through three stages:

1. Selection: Every single element of the current generation is evaluated for its fitness. This implies the development of an explicit objective function that plots attributes to outcomes or empirical measurements of each individual in the current generation. Blouses, for example, might be chosen to maximize style and fit feedback. Eventually, these individuals from the current generation can join a mating pool adopting selection procedures like "select the N fittest individuals" or "select individuals with a probability proportional to their fitness" (e.g., biased roulette-wheel selection).

2. Recombination: Individuals in the mating pool are bred to produce new individuals that are hopefully desirable and novel because they were created by decomposing two good parents and using the resulting elements to compose a child. There exists a wide assortment of procedures that can implement recombination, and there is a common feature among them: they employ a random mix of features from each parent against various implementations of

[27] https://multithreaded.stitchfix.com/blog/2016/07/14/data-driven-fashion-design/

assembled features. For instance, Stitch Fix's system might be considering sleeve type, sleeve length, and sleeve fabric as a unit.

Moreover, it is possible to deviate from a pure genetic algorithm by measuring the selected feature as a whole, rather than just evaluating the individual. Subsequently, the algorithm can exploit this broader knowledge in proposing which genes to select from each parent.

3. Mutation: Diversity and originality are launched into new generations by randomly changing alleles. The scope of such mutations is to explore the "vicinity" of the solution space, through an arbitrary walk. The distance of this vicinity depends on the type of mutations that are deployed. For example, the values of different alleles can be proportionally associated to the observed alleles' distribution or pushed into their extremes to achieve a more aggressive search (e.g., boundary mutation).

Stitch Fix can rely on a unique resource that can be leveraged to improve the efficiency of this search: a team of professional human fashion designers whose judgments indicate promising paths through the solution space. Stitch Fix's styling process (the choice of 5 recommended items to send each client) offers a model with which is possible to integrate and leverage the complementary abilities of humans and machines, where the latter recommend a generation of new designs that are then curated by human designers.