VAASAN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES

Ritika Giridhar

MACHINE LEARNING IN PERSONALIZATION

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Ritika Giridhar
Vaasa, Finland
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VAASAN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES
Information Technology

ABSTRACT

Author	Ritika Giridhar
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Personalization has become an increasingly important aspect of human-computer interaction in recent years as it enables the adaption and customization of products and services to suit the unique needs and preferences of individual users. Personalization in healthcare has been used in a variety of areas such as precision medicine, personalized medicine, and remote patient monitoring, to provide a more useful and satisfying patient experience.

Artificial intelligence and machine learning have the potential to significantly enhance personalization in healthcare by enabling the analysis of large amounts of patient data to make predictions and provide more accurate and personalized recommendations for treatment and care.

This research project aims to investigate the applications of machine learning in personalization, with a focus on how it can be used to improve diagnosis and treatment outcomes for patients with life-threatening diseases and show why personalized treatment is necessary in 2023. The research will be conducted through a combination of literature review, a user study on how Spotify employs personalization to enhance customer satisfaction, and a case study to demonstrate how AI can optimize the personalized treatment of age-related macular degeneration.

Keywords	Machine learning, artificial intelligence, personalization

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LIST OF ABBREVIATIONS

AI	Artificial intelligence
AIED	Artificial intelligence in education
AMD	Age-related macular degeneration
CSF	Cerebrospinal fluid
LLM	Large language model
ML	Machine learning

1 INTRODUCTION

“Personalization is when you go into a bar and sit down, and the bartender puts a whiskey in front of you without having to ask what you want” (Bezos, 2000). Personalization is a concept that predates the creation of the Internet and is therefore more widespread than one thinks. Nevertheless, it is certain that more than any other type of technology, the Internet has promoted a sizable portion of the practice's interest, and assisted in its expansion. An individual can receive a personalized user experience by having web pages that are adapted to their attributes (interests), actions (opening a website link), intent (purchasing something), or any other variable that can be discovered and associated with them.

Based on a survey done by Salesforce (2020), 92% of marketers state that their customers and prospects expect a personalized experience. When it comes to offering users value, artificial intelligence (AI) is pioneering new ground. The collection, storage, management, and retrieval of information that might help with the development and administration of one-on-one or personalized business services can be automated with AI. AI is able to teach machines to discover patterns in vast volumes of data by utilizing technologies like deep learning, genetic algorithms, and natural language processing (Kumar et al., 2019).

Technology, data, and analytics have made major strides in making genuinely personalized healthcare possible on a scale that was unimaginable just a few years ago. The healthcare sector is significantly behind in terms of personalization strategies and algorithms, despite industry titans like Spotify, Amazon, and Meta already utilizing them to revolutionize their businesses. The perspectives of the patient and the healthcare organization can be combined to provide truly tailored medical care.

Consumers who receive personalized healthcare are acknowledged as distinct individuals with specific health histories and circumstances, receive pertinent information, have a simple experience, and have better health results. For the business, this entails enhanced consumer understanding, using those data to adapt the channel, timing, and messaging, as well as offering curated products and solutions (Adigozel & Wilson, 2022).

This research project aims to investigate the applications of machine learning in personalization, with a focus on how it can be used to enhance diagnosis and treatment outcomes for patients with life-threatening diseases, and show why personalized treatment is necessary in 2023. The research will be conducted through a combination of literature review, a user study on how Spotify uses personalization to provide a superior user experience, and a case study to show how AI can optimize the personalized treatment of age-related macular degeneration.

2 BACKGROUND, RESEARCH PROBLEM(S) AND PURPOSE OF THE RESEARCH

2.1 The History of Personalization

When one thinks of the word “personalization,” they immediately think of a service that is tailored to a customer’s needs by means of data collected via various social media channels and/or search outlets. In fact, virtual assistants like Siri and Alexa also help in collecting data, even when they’re “not actively listening” (Ha et al., 2020). But that was not the case about 12 years ago.

One of the first marketing channels to establish personalization was email, where it only required adding the recipient's name to the message. However, the email's content remained the same for all recipients, and no one was interested in expanding their email advertising to their website(s). But email personalization swiftly gained popularity, with 65% of German businesses focusing on email advertising by 2011 (Schirl, 2021).

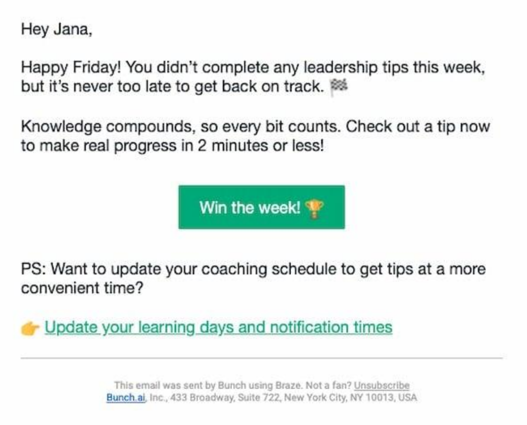


Figure 1. Example of a personalized email (Hubspot, 2022).

Personalization has always placed a significant emphasis on two factors: the data provided by technology that tracks user behavior (such as cookies), and the people who manually build up business logic to deliver individual user experiences based on that data. Marketers can then manually design audience segments using this data. These segments, which may contain a variety of data like consumer status (first-time vs. recurring), demographic information (age, income, gender), and location, can be rather complicated. Marketers are then responsible with developing distinctive marketing assets for each segment after the segments have been determined (Engagency, 2021).

Due to the high number of elements that must be routinely updated and manually modified, this form of personalization is, regrettably, quite constrained, and becomes progressively unmanageable. Brands are compelled to personalize through personas because it relies on literal "human power." Even when they are divided into smaller groups, personas are still basically big groups of people— they aren't really tailored to the person. Thus, in order to satisfy the demands of today's consumers, organizations must move away from personifying content for personas and toward individuals.

2.2 The Impact of COVID-19 on India's Healthcare System

India is a developing country with a population of around 1,417 billion, with 5,3% making up the elderly and 16,4% living in poverty. In 2020, India released the report of the National Blindness and Visual Impairment Survey, in it was reported that the country had met its target reduction of blindness and visual impairment by nearly 47% and 52% respectively, implying that the number of visually impaired people in India has been reduced to nearly 34 million, compared to WHO estimates of 62 million in 2010 (Kumar & Vashist, 2020).

Despite the fact that India has a cost-effective health-care system— with free inpatient and outpatient treatments at government institutions for Indian citizens— its public healthcare system remains overcrowded and underfunded. India's out-of-pocket health expenditure is among the highest in the world, at 63% in 2018 (Karwa & Deo, 2022). The COVID-19 pandemic has shifted the healthcare system's priorities, leaving it not only overwhelmed but also with limited capacity to provide services previously extended to communities; hospitals and healthcare facilities, overburdened with COVID-19 patients, are making it difficult for other patients with acute or chronic illnesses to access standard care (Khetrapal & Bhatia, 2020).

Even in the late stages of the disease, COVID-19 could be a causal or triggering factor for intracranial hypertension (IH), particularly in high-risk individuals (Rajabi et al., 2020). IH is caused by an increase in the pressure of the fluid surrounding the brain (cerebro-spinal fluid, or CSF). Increased CSF pressure can result in two complications: severe headache and vision loss. If the high CSF pressure is not treated, it might lead to permanent vision loss or blindness.

One major indicator of IH is the swelling of one or both of the optic nerves. This is detected using a retinal scan of the eye, as well as by carrying out a single field test of the eyes. A qualified ophthalmologist is necessary for this, and the patient's issues will be handled by the doctor in less than 2 to 2,5 minutes, with little to no medical history taken (The Indian Express, 2017). Unlike qualified optometrists, ophthalmologists are limited in India, especially in rural areas where people are either unaware of or unable to afford eye tests.

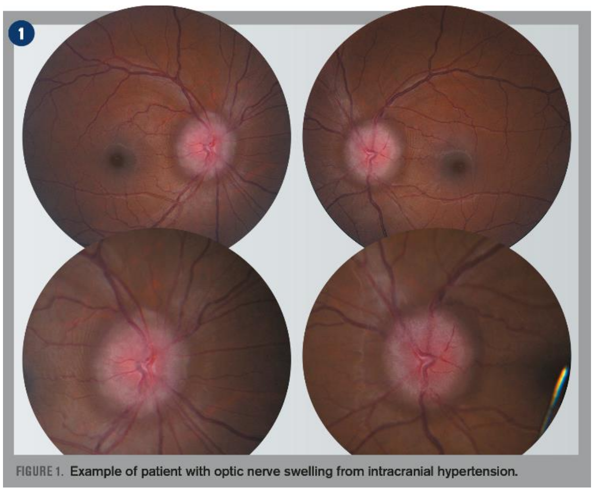


Figure 2. Example of a patient with optic nerve swelling from intracranial hypertension (Hill, 2018).

A computerized eye testing machine is usually what is used during an eye test. It is easy to use and only needs the assistance of a trained optometrist. The machine calculates the amount of lens power required to focus light onto the retina, which is located in the back of your eye. Although it needs to be refined, the machine provides an accurate prescription (España, 2017). This begs the question— can the computerized eye testing machine be equipped with enough smarts to automatically discern abnormalities? Could AI-enabled devices be made widely available to non-specialist physicians or medical technicians—and reduce the burden on the health care system?

2.2.1 How Can Personalized Healthcare Help Ease the Strain on India's Healthcare System?

Personalized healthcare has the potential to help ease the strain on India's healthcare system by improving the efficiency and effectiveness of healthcare services, as well as by reducing the burden on healthcare providers and facilities.

One way that personalized healthcare can help is by reducing the number of unnecessary or ineffective medical treatments and procedures. By tailoring treatments and interventions to the individual needs and characteristics of each patient, healthcare providers can ensure that patients receive the right care, at the right time, and in the right way. This can help reduce healthcare costs and free up resources that can be used to treat other patients.

Personalized healthcare can also help improve patient outcomes, which can reduce the need for follow-up visits and readmissions. By tailoring care to the unique needs and preferences of each patient, healthcare providers can help ensure that patients receive the best possible care, which can help reduce the need for additional medical interventions and hospitalizations.

Another way that personalized healthcare can help ease the strain on India's healthcare system is by leveraging technology and data to enable remote patient monitoring and telemedicine. By allowing patients to receive care from a distance, healthcare providers can reduce the burden on hospitals and clinics, as well as improve access to care for patients who live in remote or underserved areas. This can also help reduce the risk of infection and minimize the need for patients to travel to healthcare facilities.

Overall, personalized healthcare has the potential to improve the efficiency, effectiveness, and accessibility of healthcare services in India, which can help ease the strain on the healthcare system and improve patient outcomes. However, it's important to ensure that personalized healthcare is implemented responsibly and equitably, and that all patients have access to high-quality personalized healthcare experiences, regardless of their background or socio-economic status.

2.3 Artificial Intelligence, Personalization and the Field of Ophthalmology

Numerous genes and their variations have been identified by scientists as having the ability to impact sight and eye health. Based on this research, it is evident that an early diagnosis via genetic testing can help evaluate patients' problems in order to set-up proper treatment plan(s) and follow-up care to avoid visual complications later in life. Knowing the family's history is important for hereditary eye disorders since it can help members of the family who have similar eye diseases or predispositions. As a result, gathering information from a thorough examination, as well as a comprehensive assessment of previous medical disease by ophthalmologists, followed by consultation with geneticists, can help develop a roadmap for making diagnosis and treatment precise and helpful (Singh & Tyagi, 2018).

Ophthalmology has been an early pioneer in personalized medicine— understanding the molecular causes of eye diseases is the foundation of personalized ophthalmology. Adoption of personalized treatments involves two key areas of focus: disease categorization and individualization. Individualization spans all elements of patient management, from optimized genetic counseling and conventional medications to trials of innovative DNA-based therapeutics. Disease categorization is based on phenotypic and genetic assessment, which leads to molecular diagnosis (Porter & Black, 2014).

Ophthalmic applications of AI are not new. In 1976, the CASNET-based glaucoma consultation program established the viability of employing AI's machine learning

(ML) element in clinical practice. The most promising AI methods are now being developed for diabetic retinopathy (Google, 2016), age-related macular degeneration, and retinopathy of prematurity. AI models for glaucoma, keratoconus, cataract, and other anterior segment illnesses, as well as oculoplastic surgery, are already available in the market (Honavar, 2022).

This research report thus aims to answer the question 'can personalized health care be used to detect defects in the eye? If so, how?' How can the ML algorithm be optimized in such a way that it picks the optimal treatment for a particular eye disease, based on the patient's condition, medical history and financial constraints? Finally, why is personalized healthcare so necessary in 2023?

2.4 Risks Involved in Personalized Healthcare

In the context of healthcare, personalized treatment can carry several risks (Anderson & Agarwal, 2011; Cahan et al., 2019; Krahe, Milligan & Reilly, 2019), including:

Misdiagnosis or incorrect treatment: If the personalized treatment is not based on accurate and comprehensive medical data, there is a risk that the diagnosis and treatment plan could be incorrect or ineffective.

Privacy and security concerns: Personalized treatment often requires the collection and analysis of sensitive health information, which could be vulnerable to privacy breaches or cyber-attacks.

Cost: Personalized treatment can be expensive, and some patients may not be able to afford it, which could lead to unequal access to healthcare.

Bias and discrimination: Personalized treatment may be influenced by social and cultural factors, leading to bias and discrimination against certain populations or individuals.

Ethical concerns: Personalized treatment raises ethical issues related to the use of personal data, informed consent, and the potential exploitation of vulnerable populations (see section 6.1).

It's crucial to highlight that these risks aren't limited to personalized medicine— a lot of them extend to healthcare more broadly. Personalized treatment, on the other hand, may necessitate additional measures to address these concerns and guarantee that patients receive safe, effective, and equal treatment. While these risks exist, they will not be addressed as it is out of the scope of this thesis.

3 THEORETICAL FRAME OF REFERENCE

For the past 5 years, the term "personalization" has been mentioned in numerous contexts, with organizations in a variety of industries using it to various degrees of usefulness and success. Personalization is not only a necessary ability, it is a must-have for any firm— whether it is an online company, a brick-and-mortar participant, or a behind-the-scenes manufacturer or supplier.

Personalization is extremely successful at building long-term commitment and engagement. Recurring interactions provide more data from which businesses can design increasingly relevant experiences, resulting in a flywheel effect that generates high, long-term customer lifetime value and loyalty (Arora et al., 2021). Abraham et al. (2017) predict that over the next 5 years in 3 sectors alone— retail, health care and financial services— personalization will push a revenue of more than $500 billion to those 15% of companies that get it right.

3.1 Personalization in Retail

The pandemic has changed the way people shop for the better part of the last three years. The way consumers buy things has been altered permanently, with more people choosing to shop online as opposed to in-person stores. Retail personalization is the process of offering an individualized journey to each shopper spanning every single click and channel, based on historical data and real-time shopper intent, driven by consumer and product intelligence. Personalization in retail has the ultimate goal of making customers feel unique, special, and emotionally invested in order to improve their purchasing experience (Tyrväinen, Karjaluoto, & Saarijärvi, 2020).

Personalization in typical in-person stores refers to serving consumers face-to-face to meet their demands. Retailers may better observe client behavior, collect customer data, assess their needs, and deliver personalized services by integrating digital devices in brick-and-mortar storefronts (Wetzlinger et al., 2017). Using various personalization methods, companies can track their consumers' historical purchasing habits in the online environment. They can then decide what and how to display based on the data they have gathered.

The inclusion of digital technologies into the purchasing journey of consumers has enabled a new method of value creation and capture. Megatrends such as the increased usage of smartphones, AI, and real-time big data analytics are becoming increasingly essential in omnichannel retail personalization initiatives. Omnichannel retailing encompasses all offline, online, and mobile channels through which customers can connect with a merchant in a variety of ways. Personalization has become even more crucial in the context of omnichannel since it has the potential to create more individualized customer experiences (Zhang, Agarwal, & Lucas, 2011).

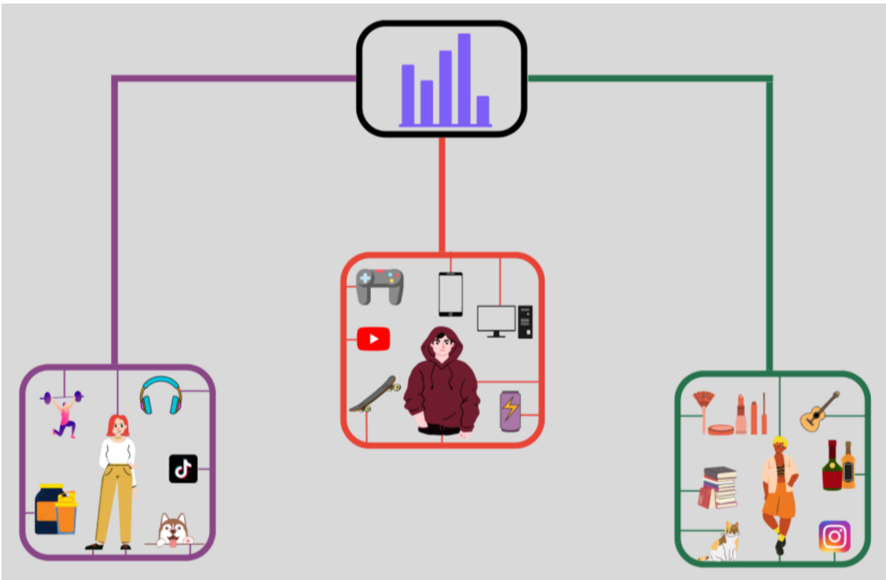


Figure 3. Visualization of various interests of customers that are used to get analytics and data for personalized content.

Consumer-centric smart retail developments in technology also enhance retailers' efforts to customize in-store personalization to each customer's demands. Using technology-driven methods, these merchants can utilize context-specific, traditional kinds of personalization through their workers, as well as data about customers' historical activity. With the emergence of smart retail technologies, it is now possible to combine aspects from the two categories to generate technology-enabled personalization (TEP) in stores. TEP has been defined by Riegger et al. (2020) as the integration of physical and digital personalization attributes at the point of sale to present individual customers with appropriate, context-specific information based on historic and real-time data. As a result, all contacts between the shop and the customer involve digital devices (for e.g., interactive screens).

Relevance is another essential consumer expectation, regardless of age. Understanding where the consumer is and what they want at the time shows them that you are still relevant to their lifestyle, which keeps them loyal. Boomers are becoming more digitally savvy; as they spend more money online, they are establishing a distinct set of expectations for the businesses with whom they interact. According to research by BCG (2022), brands that create a personalized experience see a revenue increase of 6-10% compared to brands that don't.

The fashion industry is one of the largest industries in the world, with Euromonitor (2021) estimating that the world's apparel retail market is expected a 6,1% growth in 2022-2023 to $1,95 billion in 2023. However, excessive inflation and detrimental feedback from consumers have already slowed growth rates in the second half of 2022, with the slowdown likely to last well beyond 2023. The biggest difficulty that fashion retailers face is a lack of significant insights based on solid statistics. Computer vision and deep learning can be quite useful in staying ahead of the curve. Image recognition technology also assists business owners in gathering data, processing it, and gaining actionable information for successful trend forecasting (Gong & Khalid, 2020).

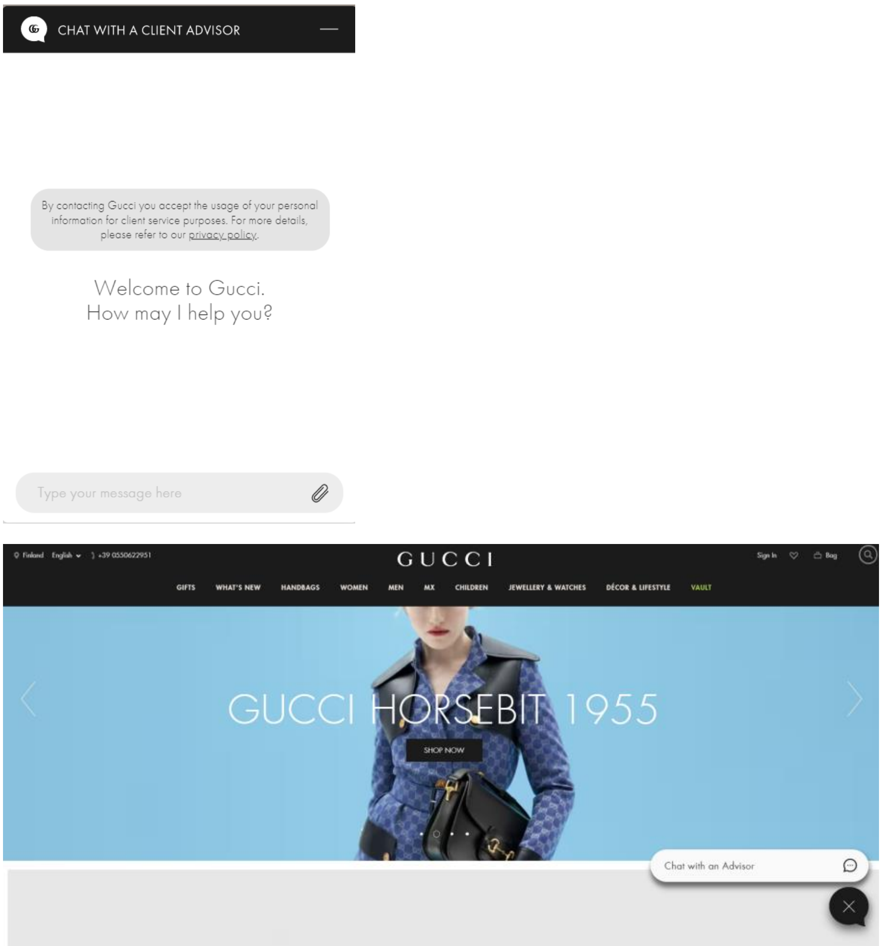


Figure 4. Implementation of a chatbot in Gucci's online store to help get personalized advice from their client advisor.

The algorithmic purchasing choice route for consumers can allow retailers to communicate with prospective customers instantly and without the necessity of a middleman. As illustrated in figure 4, the benefits of employing AI assistants (for e.g., Siri, Alexa) establish numerous aspects that influence perceived utilitarian or hedonic values and so shape user willingness. Combining data-driven solutions can help to foster the establishment of trustworthy customer-employee interactions while also optimizing user engagement, sales performance, distinct purchasing decisions, and personalized shopping experiences (Kliestik et al., 2022).

Chabane et al. (2022) discuss the use of traditional ML and deep learning (DL) algorithms to create an online system to assist Canadian customers in creating personalized intelligent weekly shopping lists based on their own personal purchase history, weekly specials offered in nearby retailers, and product cost and availability information. This is accomplished through the use of a clustering analysis, followed by computational tests to compare many classic ML techniques with their new DL approach based on the usage of a gated recurrent unit (GRU)-based recurrent neural network (RNN) architecture.

Hawkins (2022) concludes that while pertinent research has looked into whether data visualization tools can be significant in retail analytics by optimizing experiential shopping, future research ought to look into analytical methods during metaverse experiences. During retail livestreaming in the future, focus should be placed toward immersive virtual shopping experiences.

Personalization in retail has become increasingly important as customers expect more tailored and relevant experiences. By providing personalized recommendations and promotions, retailers can improve customer engagement, loyalty, and ultimately drive sales. Additionally, personalized experiences can help retailers better understand their customers and make more informed business decisions based on customer insights. However, it's important for retailers to be transparent about how they collect and use customer data, as well as ensure they are following data privacy regulations and protecting their customers' data.

3.2 Personalization in Advertising

Consider an example of a customer’s purchase journey. A consumer is interested in a mascara they saw on YouTube. They search for that mascara on Google, and read reviews about it from a few websites. While scrolling on Instagram, they come across a sponsored post from the mascara company, and interact with it. Over the next few days, they are frequently exposed to ads about that mascara while using social media or browsing the web. After seeing an affiliate code for the mascara from their favorite beauty guru, they place an order on a beauty giant’s website. Satisfied with their product, they describe their usage experience on TikTok, along with a product review.

What the consumer is unaware of is that a large portion of this journey is led by automated systems. Google's search algorithm (2023) generates the search results by sorting through hundreds of billions of websites and other information in their Search Index to get the most relevant and useful results. Through website morphing, the content on the websites is altered based on the profile of the consumer. Ads that they view recurringly are supplied via retargeting algorithms using real-time bidding, as shown in figure 5. The coupon with the tailored price is generated at precisely the appropriate time by the firm's pricing engine. Finally, social listening engines collect and evaluate their social media posts for mood and feedback (Ma & Sun, 2020).

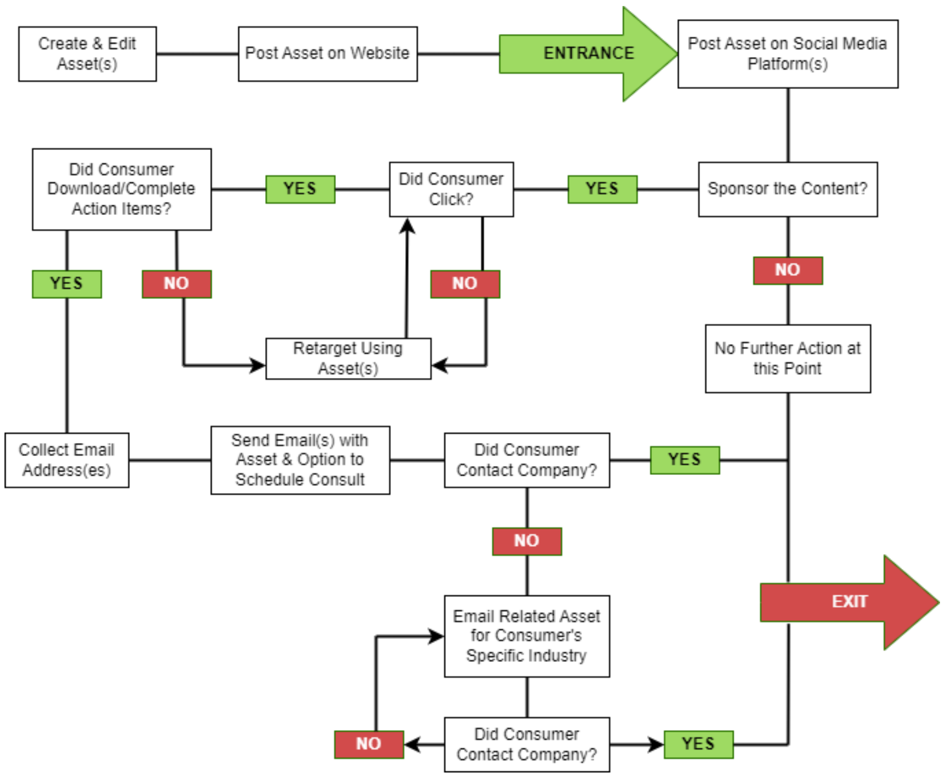


Figure 5. Flowchart to show how internet ads work (referred from: Ampliphi, 2019).

Visual recognition software is currently assisting vendors in developing a deeper understanding of how consumers behave. For e.g., the images and videos that a person likes or shares on social media provide insights into the products that they like; by using ML, the algorithms used by different social media giants (for e.g., Instagram, Twitter, Snapchat) can quickly identify distinctive characteristics coming from image or video streams and assist in determining which ad should be delivered to achieve the best results (Micu et al., 2021). Advertisers are able to use the Internet to contact, track, and persuade users based on behavioral data acquisition. A user's digital footprint— encompassing location, activities, in-app behavior, likes, and shares— leads to a digital profile shared by many companies that can be utilized to improve the effectiveness of advertising messages (Radesky et al., 2020).

Firm-consumer interactions are becoming more personalized and omnipresent, resulting in substantially digitized footprints. Mobile devices allow marketers to follow consumers' digital mobile search activities as well as their physical movements in offline locations (where), and to target them with promotions at the right time when they are weighing their alternatives and about to buy (when) (Tong, Luo & Xu, 2019). As a result, the abundance of data has prompted companies to invest heavily in ML to enhance their marketing capabilities. According to BCC Research (2022), the global market of ML-enabled solutions is estimated to grow at a rate of 39,4% from 2021 to 2026, reaching $90 billion by 2026.

Deploying the right ML algorithms can have significant effects on the overall performance of a marketing campaign for both large and small businesses; predictive analytics approaches assist make campaigns more visible and imaginative. ML and AI methods assist in refining the targeted clients and achieving beneficial outcomes through digital advertising—from a company making nanofibers to one that produces massive machineries. As a result, in order to optimize revenues, businesses are now investing more money into AI and ML technologies for their advertising budgets rather than traditional media such as newspapers or flyers (Shah et al., 2020).

Mogaji, Olaleye, & Ukpabi (2020) propose combining all big data and consumer analytics collected via AI from different sources in order to have a deeper knowledge of consumers as individuals. AI is anticipated to be able to create customized adverts by selecting from a variety of creative materials and fitting them into a template to distribute to consumers. These adverts will then be distributed digitally, highlighting an impact on programmatic advertising— a method of purchasing advertisements automatically, with computers utilizing data to choose which to purchase and how much to pay for them.

Personalization in advertising can help improve customer engagement, increase brand loyalty, and drive conversions. By delivering more relevant and timely marketing messages, businesses can improve their chances of capturing the attention of their target audience and inspiring them to take action. However, it's important for businesses to be transparent about how they collect and use customer data and ensure they are following data privacy regulations. Customers may become wary if they feel their personal data is being misused, so it's essential to build trust with them and maintain their privacy throughout the personalization process.

3.3 Personalization in Education

Online courses are now even more accessible than ever, with platforms like Coursera and edX offering courses from different universities located all around the globe. Using AI and ML methodologies, educational platforms could precisely determine a learner's abilities. Personalized learning is defined as "instruction in which the pace of learning and instructional approach are optimized for each learner's needs." Learning objectives, instructional methods, and content may differ depending on the needs of the learner (Luan & Tsai, 2021). With the rapid developments in AI and data science, precise and rich learning data may be gathered to show distinctive learning patterns and requirements, giving the user an "optimum" personalized learning path or assessment. As a result, there is a clear gradual shift away from a one-size-fits-all approach to education and toward a more precision-based approach (Lu et al., 2018).

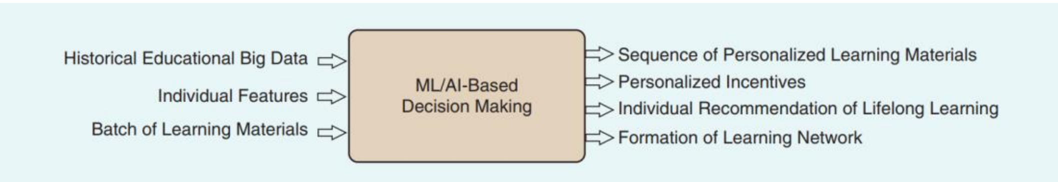


Figure 6. How ML/AI-based decision making affects personalized education (Maghsudi et al., 2021).

ML addresses the issue of how to build computer systems that can learn automatically from previous interactions without the need for explicit programming. ML algorithms can classify data and patterns, create new models and insights, and generate predictions and suggestions that are personalized to the needs and conditions of each individual (Wu et al., 2017). By motivating students to interact, personalized education platforms allow for autonomous network formation. Furthermore, the platforms can establish relationships between those learners who meet certain similarity criteria and can thus be valuable to each other for cooperation, inspiration, and motivation.

AI has already been used in predicting students' accomplishments, identifying at-risk students at an earlier stage, determining the main factors that will affect students' performance, conducting performance evaluations, providing descriptive information about them and contributing to teaching processes, creating flexible, efficient learning tools, and implementing adaptive learning techniques, according to Bozkurt et al. (2021).

To a significant degree, personalized education has been confined only to a particular type of recommendation system (see section 5.2.5), despite the fact that its potential extends far beyond recommending a series of lectures on an online platform that may be of interest to the user in question (Maghsudi et al., 2021). The ever-increasing availability of online learning materials for students makes it increasingly difficult to find specific information from data pools, which are often based on ML techniques and algorithms. Personalization technologies, such as adaptive e-learning and recommendation systems, try to reduce this complexity (Khanal et al., 2019). Unfortunately, difficulties like data scarcity, scalability, and accuracy continue to exist.

Education 4.0 refers to the most recent wave of educational innovation, which is highlighted by the incorporation of digital technologies and personalized learning.

AI plays an important part in Education 4.0 by evaluating learning data from students to identify their greatest assets, limitations, and learning preferences. AI-powered systems can use this data to develop personalized learning plans, recommend appropriate learning materials and activities, and alter the pace and difficulty of the learning content to meet the needs of each learner. Ciolacu et al. (2018) mention that education 4.0, fueled by smart sensors and wearable devices, is advancing learning analytics by merging educational activities (online activities) with sensor data (real time data).

However, the use of AI in education creates significant ethical and privacy problems, such as data privacy, algorithmic prejudice, and the possibility of automation replacing human teachers. As a result, it is critical to thoroughly analyze the ethical and social consequences of AI implementation in education, as well as to guarantee that it is utilized responsibly and transparently. According to Holmes et al. (2022), without a more targeted approach to the ethics of AI in education (AIED), the community's work may remain largely invisible to the rest of the AI subfields and related policies, potentially restricting the impact of AIED research on the growing human-oriented, real-world uses of AI. With its deep understanding of “human” AI users and AI's potential to support human learning and behavior change, AIED provides a critical perspective on how people interact with and change as a result of interactions with AI systems, as well as the potential advantages and dangers of engaging with such systems.

Personalization in education can help improve student engagement, motivation, and learning outcomes, as well as help teachers better understand and support each student's unique needs. However, it's important to ensure that personalization is used responsibly and fairly, and that all students have access to high-quality personalized learning experiences, regardless of their background or socio-economic status.

3.4 Personalization in Healthcare

Healthcare is one of the fastest growing industries today, and it is undergoing a thorough global overhaul and transition. According to the 2023 Global Medical Trends Survey, the global healthcare benefits cost trend increased from 8.2% in 2021 to a higher-than-expected 8.8% in 2022, and is expected to rise even more in 2023 to a staggeringly high worldwide average of 10% (Kilduff, 2022). ML has the potential to reduce the rising medical expenses while also assisting in the establishment of a stronger patient-doctor relationship (Bhardwaj, Nambiar, & Dutta, 2017). Reinforcement learning has been found to have effective uses in personalized medicine throughout the last decade.

To assure accuracy for all populations and to achieve the performance levels required for scaled success, healthcare AI should be trained and verified using population-representative data (Matheny, Whicher, & Israni, 2022). By exceeding clinical systems and simulating complicated interactions among active hidden elements of data, DL has the potential to revolutionize healthcare (Ahmed et al., 2020). According to Mukherjee et al. (2020), by combining fog, edge, and cloud computing, the Internet of healthcare things (IoHT) can become a demanding application for personalized healthcare.

In the case of hospital readmission, personalized treatment is imperative. A survey found that one-fifth of post-surgery patients were readmitted to the hospital. One-third of those readmissions may have been prevented if a proper personalized healthcare plan with surveillance had been in place. According to researchers, inadequate coordination of care was responsible for $25-45 billion in wasteful spending in local hospitals in the United States due to preventable issues and avoidable hospital readmissions (Ahamed & Farid, 2020).

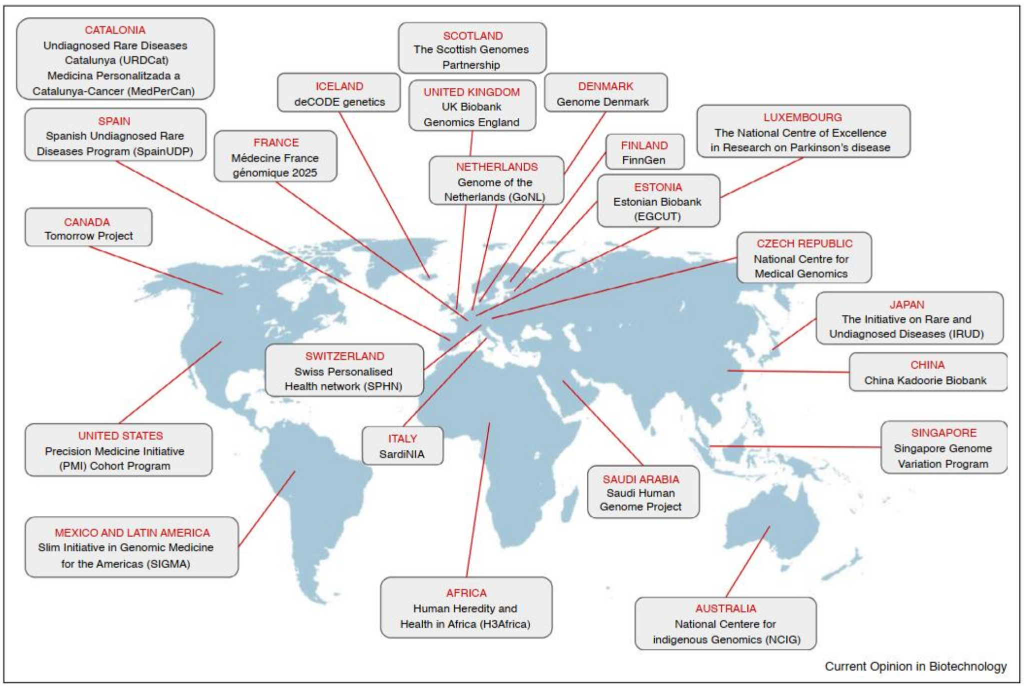


Figure 7. Geographic representation of ongoing population-scale sequencing initiatives for personalized medicine (Cirillo & Valencia, 2019).

Medical imaging involves the use of various techniques (such as X-rays, CT scans, MRIs, and so on) to create photographic images of the internal structure of a body for clinical studies and medical treatment. The accuracy of medical imaging diagnosis is determined by the level of resolution of the images produced, as well as their interpretation by an accredited expert. Traditional methods, such as Computer-Aided Diagnosis (CAD), may be unable to solve the complexity of the extracted parameters and picture information, but reinforcement learning techniques can be employed for such complicated data to improve outcomes and interpretation (Coronato et al., 2020).

The three key requirements for successful AI deployment in healthcare, according to Johnson et al. (2021), are data and security, insights and analytics, and collaborative expertise. Data and security are synonymous with complete transparency and confidence in how AI systems are educated, as well as the data and information utilized to train them. Analytics and insights are synonymous with purpose and people, where "augmented intelligence" and "actionable insights" supplement rather than replace what humans do.

Smart healthcare involves many parties, including doctors and patients, hospitals, and research organizations. By utilizing technologies such as the Internet of Things (IoT), big data, AI, and others that form the foundation of smart healthcare, Tian et al. (2019) point out how smart diagnosis allows the patient's condition and illness status to be more correctly described, allowing for the development of a personalized treatment plan. As a result, the course of treatment becomes more precise.

As an illustration, let's assume a patient exhibits symptoms such as fever, cough, and shortness of breath. A healthcare provider can enter these symptoms into an AI-powered system that understands and interprets the patient's description of their symptoms using natural language processing. The symptoms are then compared to a database of medical disorders and associated symptoms to obtain a list of potential diagnoses. The system can give a prioritized list of potential diagnoses and associated treatment options, as well as supporting evidence and likelihood estimations, to the healthcare professional. The information can then be reviewed by the healthcare provider, who can subsequently make an informed diagnostic and treatment decision.

Complex ML models are now outperforming classical models in healthcare—but they are frequently difficult to understand because to a lack of intuitiveness, difficulties in understanding, and a lack of explanation of the model's predictions (Stiglic et al., 2020). According to Bianchi et al. (2019), the quality of models generated by ML techniques is highly dependent on the dataset utilized for training. A dataset that is identical to the actual use case and has been trained on the individual observed user may provide the best activity recognition capabilities. When used correctly, ML can assist physicians, medical technicians, and doctors in making near-perfect diagnosis, selecting suitable medication(s) for the patients, identifying individuals at high risk for poor pharmaceutical results, and improving patients' overall health—all while keeping expenses low.

Personalization in healthcare can help improve patient outcomes, reduce healthcare costs, and increase patient satisfaction. By tailoring care to the unique needs and characteristics of each patient, healthcare providers can ensure that patients receive the right care, at the right time, and in the right way. However, it's important to ensure that personalization is used responsibly and equitably, and that all patients have access to high-quality personalized healthcare experiences, regardless of their background or socio-economic status. Additionally, it's important to protect patient data privacy and follow data protection regulations.

4 RESEARCH METHOLOGY

In order to have a solid background for this thesis, sufficient literature was required. The literature was in the form of papers in journals, books, and scientific articles on the web. The sources include IEEE, Springer, NHS, Towards Data Science (Medium), among others.

A user study on Spotify was done to show how machine learning algorithms are being used in daily life to provide personalized services. The AI algorithms used by Spotify were discussed, as well as its use of a type of recommendation system. Finally, a discussion was done on how Spotify's personalization methods could be used for personalized healthcare.

For the case study on personalization, a flow chart was created to understand the optimization algorithm used by the AI. This can be seen as follows-

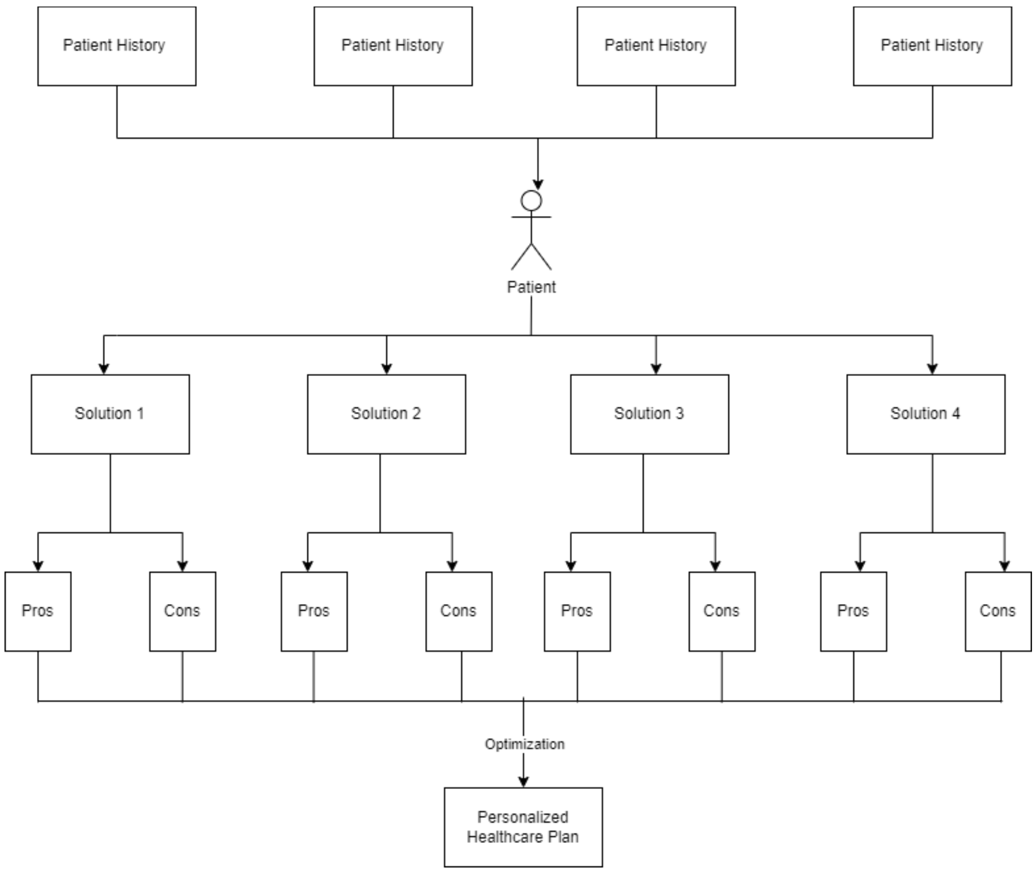


Figure 8. Flowchart showing the steps the machine learning algorithm takes to optimize personalized healthcare for a patient.

The flowchart was then customized to show how the AI would react to a particular scenario of a patient with age-related macular degeneration. Two optimization algorithms, Gradient Descent and Stochastic Gradient Descent, were taken into consideration and compared to see which would produce a better result. Finally, a recommendation system was analyzed to see how it would benefit personalized healthcare to help reduce the queue of patients in a hospital or clinic.

5 PERSONALIZATION IN DAILY LIFE

5.1 How Spotify Utilized the Concept of Personalization to Revolutionize the Music Streaming Industry

5.1.1 What is Spotify and Why is it so Popular?

"The way that individuals and cultures are represented through music and entertainment has a profound effect on society" (Tian et al., 2019). Spotify is a Swedish audio streaming and media service company launched in 2006 by Daniel Ek and Martin Lorentzon that allows people to listen to podcasts and music from every corner of the world. Users can stream over 100 million songs and 5 million podcasts at any time using their PCs, smartphones, or other internet-connected device(s). All the images shown in this section, unless referenced, were taken from the author's own Spotify account.

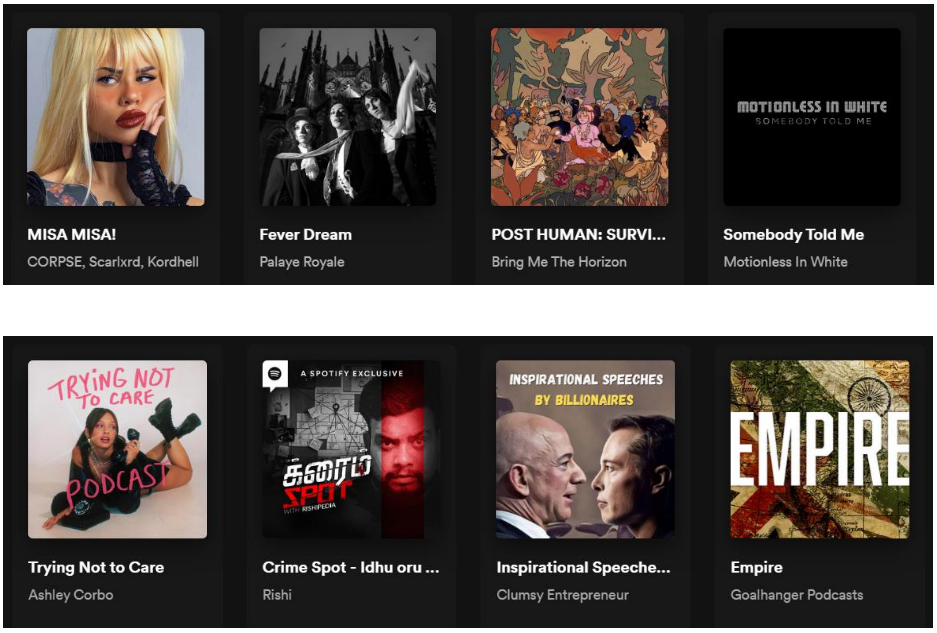


Figure 9. Different music (above) and podcasts (below) available on Spotify.

Spotify provides a paid subscription service as well as a free, ad-supported service. On the former, there are certain restrictions on what may be played on-demand, and users will see advertisements—the 30 second advertisements sometimes provide users with 30 minutes of ad-free listening. Customers who use ad-supported services can only skip a fixed number of tracks per hour (5 in Finland) and cannot download music or podcasts for offline listening. Subscribers, on the other hand, gain unrestricted access to music and podcasts after paying a monthly recurring fee ranging from 6,49€ to 18,99€ in Finland, depending on the type of Premium service chosen. Users can find music by artist, album, or genre, and they can build, edit, and share playlists (Anderson et al., 2020).

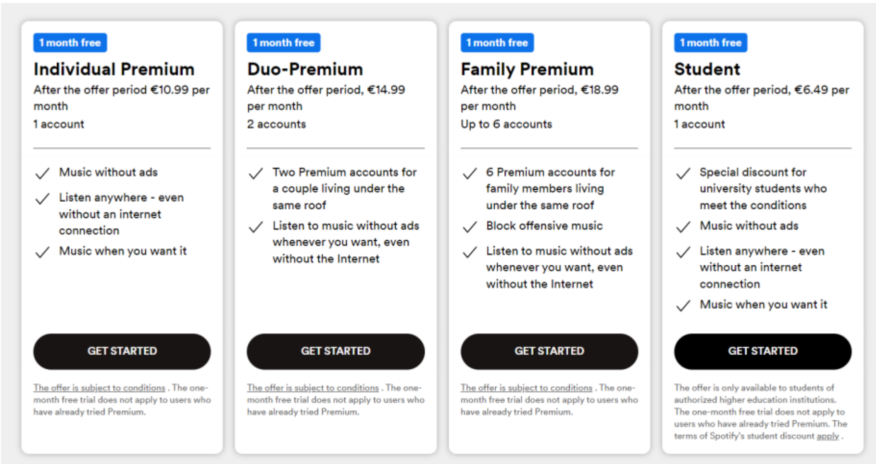
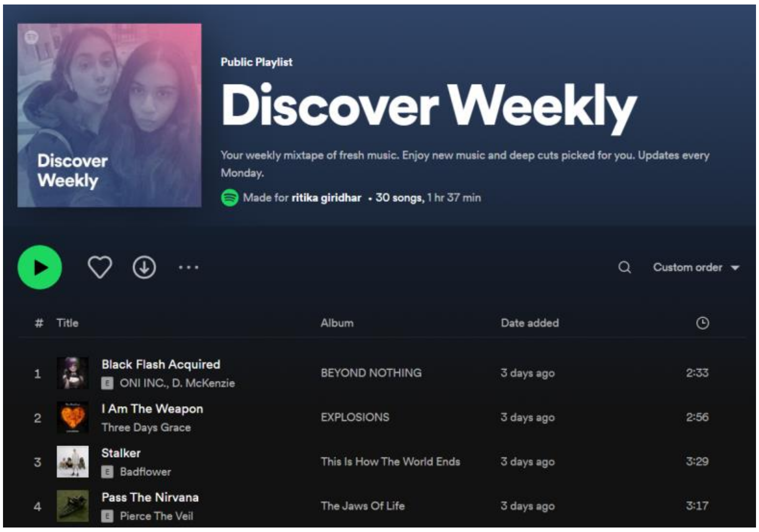
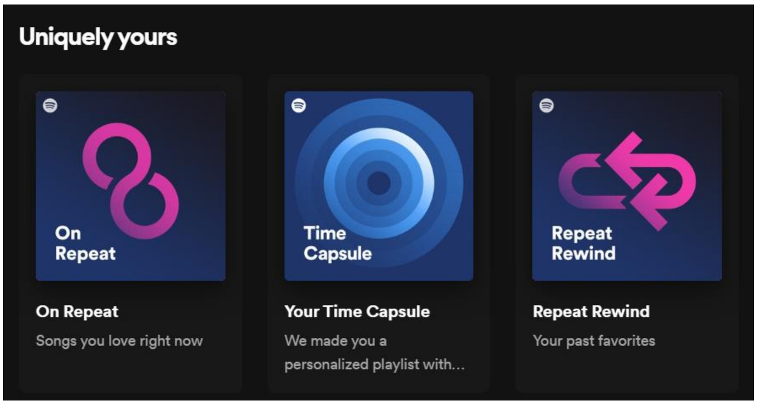


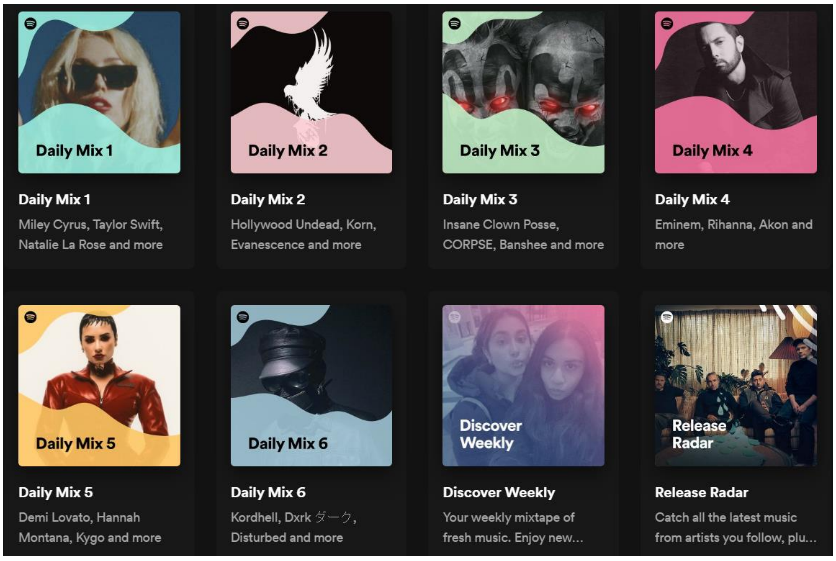
Figure 10. The different Spotify Premium options available in Finland (Spotify, 2023).

5.1.2 Artificial Intelligence Technologies Used by Spotify

Using the most recent advances in music recommendation systems, Spotify has created collections of tailored playlists and single-item recommendations, all of which are carefully selected, sorted, and presented to each individual listener (Webster, 2021). Spotify produces over 480 million "Discovery Weekly" playlists—a uniquely personalized playlist of new music— every week, as well as 6 "Daily Mix," 3 "Uniquely yours" and 10 "Your top mixes" playlists made uniquely for each user.


Discover Weekly
Public Playlist
Discover Weekly
Your weekly mixtape of fresh music. Enjoy new music and deep cuts picked for you. Updates every Monday.
Made for ritika giridhar • 30 songs, 1 hr 37 min
Custom order
Title
Album
Date added
1 Black Flash Acquired
ONI INC., D. McKenzie
BEYOND NOTHING
3 days ago
2:33
2 I Am The Weapon
Three Days Grace
EXPLOSIONS
3 days ago
2:56
3 Stalker
Badflower
This Is How The World Ends
3 days ago
3:29
4 Pass The Nirvana
Pierce The Veil
The Jaws Of Life
3 days ago
3:17


Uniquely yours
On Repeat
On Repeat
Songs you love right now
Time Capsule
Your Time Capsule
We made you a personalized playlist with...
Repeat Rewind
Repeat Rewind
Your past favorites


Daily Mix 1
Daily Mix 1
Miley Cyrus, Taylor Swift, Natalie La Rose and more
Daily Mix 2
Daily Mix 2
Hollywood Undead, Korn, Evanescence and more
Daily Mix 3
Daily Mix 3
Insane Clown Posse, CORPSE, Banshee and more
Daily Mix 4
Daily Mix 4
Eminem, Rihanna, Akon and more
Daily Mix 5
Daily Mix 5
Demi Lovato, Hannah Montana, Kygo and more
Daily Mix 6
Daily Mix 6
Kordhell, Dxrk ダーク, Disturbed and more
Discover Weekly
Discover Weekly
Your weekly mixtape of fresh music. Enjoy new...
Release Radar
Release Radar
Catch all the latest music from artists you follow, plu...

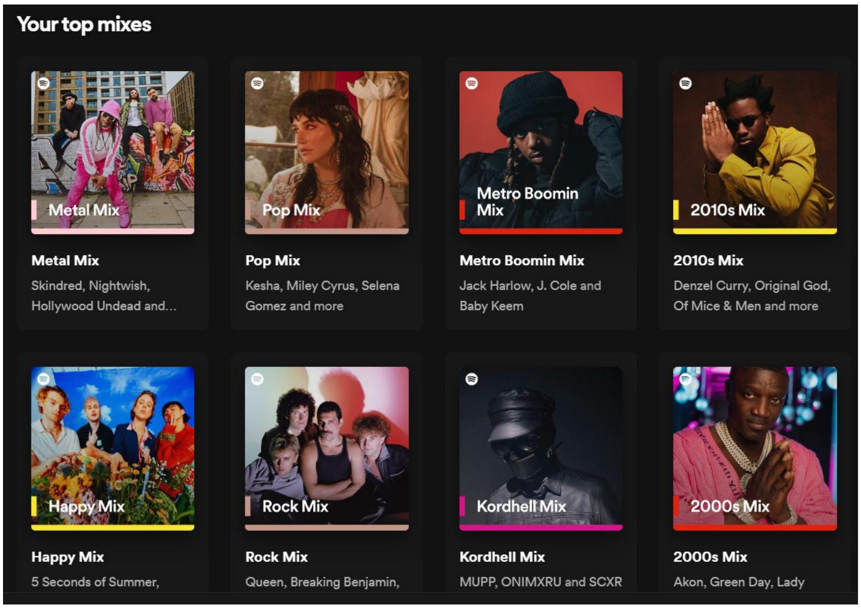


Figure 11. “Discover Weekly,” “Uniquely yours,” “Daily Mix” and “Your top mixes” playlists on Spotify.

Almost everything at Spotify is tracked, but most users are fine with it because it results in a better user experience, and personalized recommendations. This data includes, but not limited to, listener history, skipped songs, frequency of playback, stored playlists, downloaded music, and social interactions such as sharing playlists or music (Marius, 2021). For each user-made playlist, Spotify also allows the option of adding their own recommendations, “based on what’s in that playlist,” using Spotify’s version of a recommendation system (see section 5.2.5). Spotify also allows users to view what their friends and followers are listening to, either by connecting their Facebook account or by enabling the “Share my listening activity on Spotify” option.

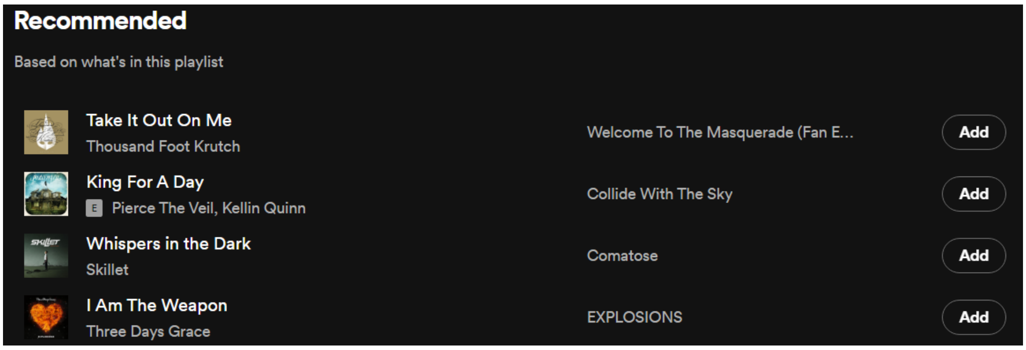


Figure 12. Spotify recommendations for a playlist.

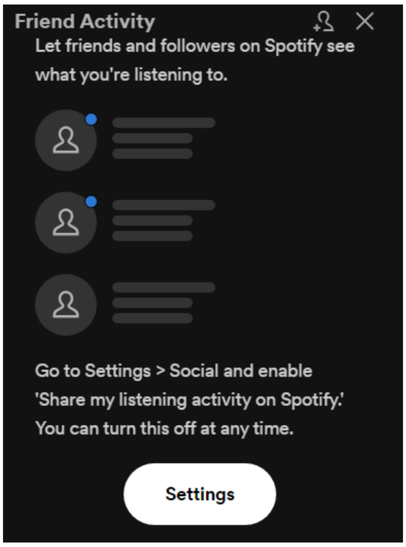


Figure 13. Friend activity on Spotify.

Along with Spotify recommendations, each playlist has a feature that allows a user to either "enhance" their playlist, or "exclude the playlist from their taste profile". With the "exclude from taste profile" functionality, users can choose to omit any playlists they follow from Spotify's customized Spotify playlists, such as their "Discover Weekly" or "Release Radar" playlists.

Figure 14. Excluding playlist from the taste profile.

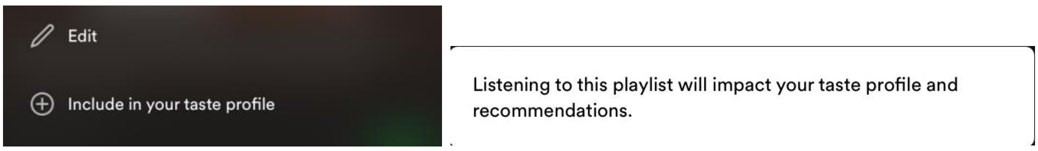


Figure 15. Including playlist from the taste profile.

The "Enhance" feature, which is found at the top of the playlist deck, enables users to quickly improve their playlist with algorithmically chosen songs that Spotify believes fit the mood of the other songs they have previously chosen for the playlist.

Figure 16. The "Enhance" feature location (left) and message when turned on (right).

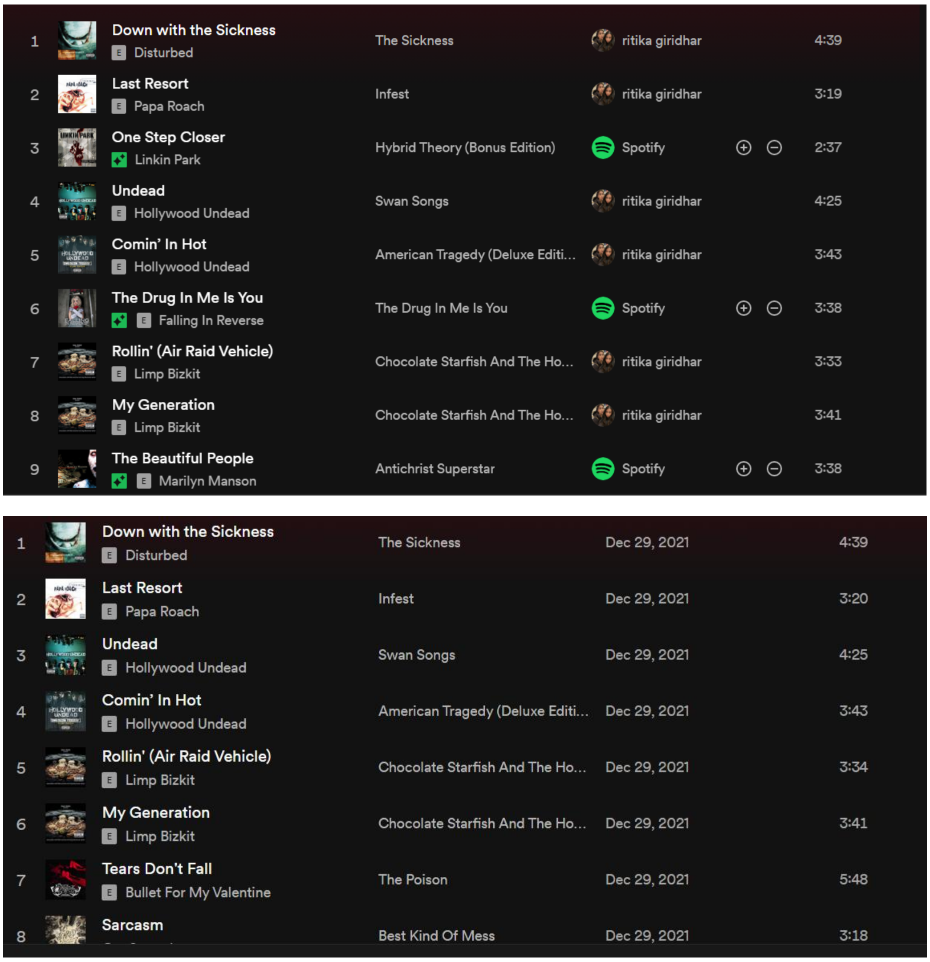


Figure 17. Playlist with the "Enhance" turned on (above) and turned off (below).

Spotify also has a viral advertising campaign called "Spotify Wrapped". Since 2016, the campaign has been launched in early December and allows users to share a collection of data about their platform usage over the previous year on social media. According to Spotify (2022), "Spotify Wrapped is all about celebrating the endless ways that millions of creators and fans connect through audio each and every day." Spotify Wrapped expanded in 2022 to categorize each user as one of Spotify's 16 listening personas based on the music they streamed, and other criteria, such as how quickly they come across new things and what decade of music they prefer. Spotify is able to build these lists and forecast the music their users want to listen to due to its enormous data repository and powerful AI engine.

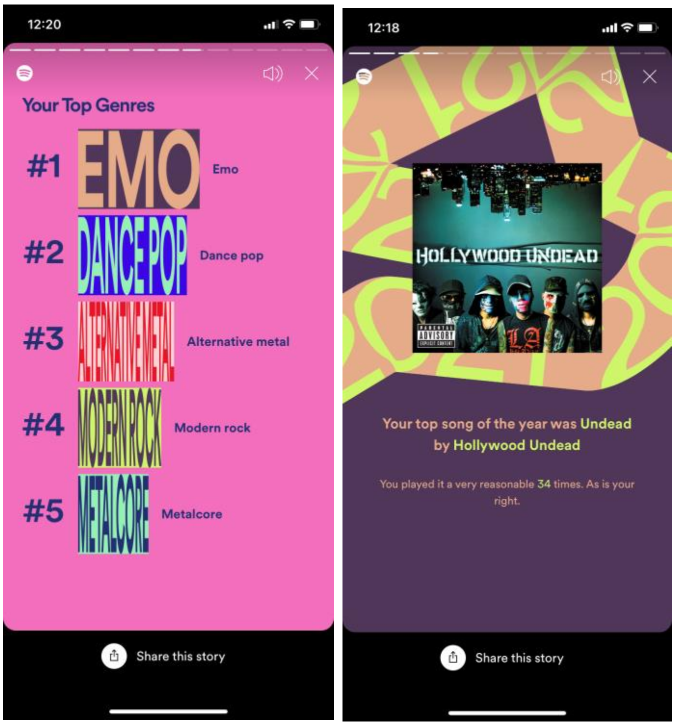


Figure 18. Some highlights from the author’s 2021 Spotify Wrapped.

Spotify's algorithms evaluate the listening behaviors of hundreds of millions of users; utilizing historical listening patterns, it draws similarities and links, then estimates future listening preferences for specific listeners. However, the Spotify shuffle algorithm(s) seems to not truly be unbiased, as Spotify tends to push certain songs over the others. For e.g., in a playlist with 140 songs on ‘shuffle’ mode, Spotify has played the songs “U Love It” (2022) and “9mm” (2021) four times more than the other songs. This could be the reason why “Blinding Lights” (2020) has more than 3 billion streams, as Spotify tends to favor this song (Bauer & Ferraro, 2021) more than the others in a playlist, be it the user’s or one of Spotify’s. More studies need to be done on the bias of their shuffle algorithm before any conclusions can be drawn.

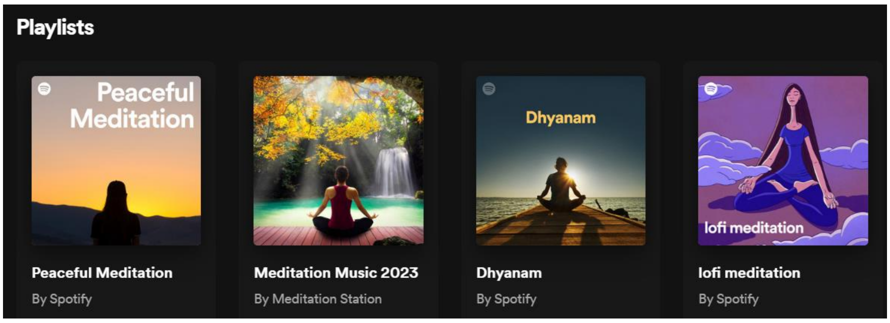
Figure 19. Number of streams "Blinding Lights" has received since 2020.

5.1.3 Spotify and Personalized Healthcare

While Spotify's personalization features are not directly applicable to healthcare, the underlying algorithms and technologies that power Spotify's recommendations can be adapted to create personalized healthcare experiences.

One way that Spotify's personalization could be applied to healthcare is through the development of personalized wellness plans. These plans could incorporate data from wearable devices and other health tracking tools, similar to how Spotify uses data on user listening habits to make personalized music recommendations. By analyzing a patient's health data, including physical activity levels, sleep patterns, and nutrition habits, personalized wellness plans could be created to address the specific needs and goals of each patient.

Another way that Spotify's personalization features could be applied to healthcare is through the development of personalized relaxation or meditation playlists. Just as Spotify uses data on user listening habits to create playlists tailored to their preferences, healthcare providers could use data on a patient's relaxation or meditation habits to create personalized playlists that promote relaxation and stress relief. This could be particularly helpful for patients with mental health conditions, such as anxiety or depression.



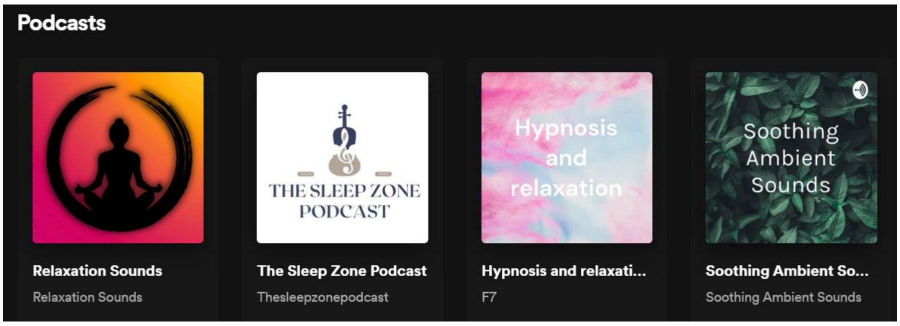


Figure 20. Different meditation playlists (above) and relaxation podcasts (below) offered by Spotify.

Additionally, Spotify's personalization algorithms could be used to create personalized workout playlists for patients undergoing physical therapy or rehabilitation. These playlists could be tailored to the patient's specific needs and limitations, and could help motivate patients to stick to their exercise regimens.

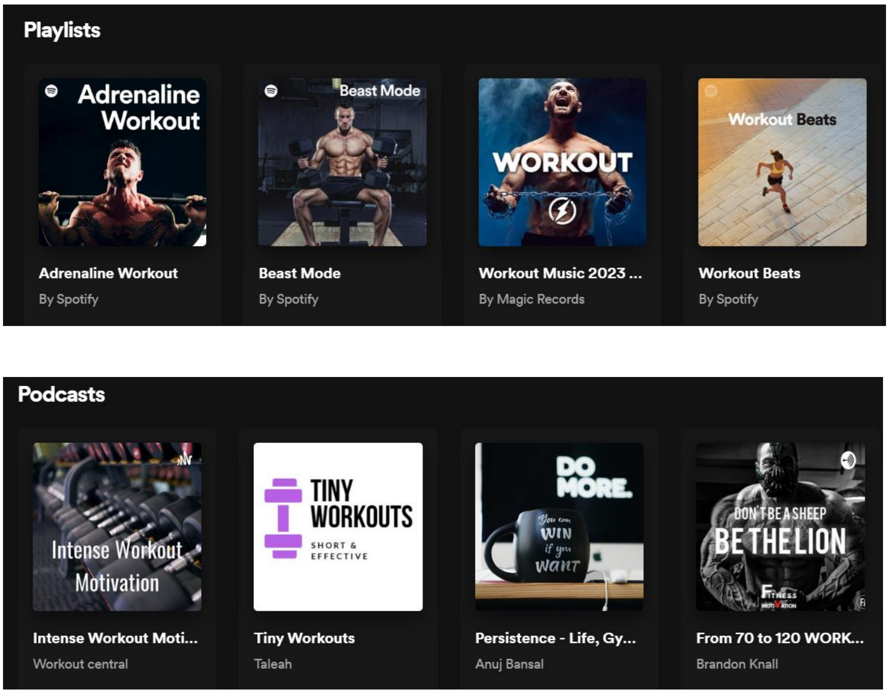


Figure 21. Different workout playlists (above) and podcasts (below) offered by Spotify.

Overall, while Spotify's personalization features are not directly applicable to healthcare, the underlying technologies and algorithms can be adapted to create personalized healthcare experiences that address the specific needs and goals of each patient.

5.2 Optimized Machine Learning to Personalize Treatment for Age-related Macular Degeneration- A Case Study

Consider a patient, Matti Meikäläinen. Matti suffers from age-related macular degeneration (AMD), a condition that affects the macula, which is the part of the eye responsible for sharp, central vision. Although AMD may not result in total blindness, losing one's central vision can make it difficult to see faces, read, drive, or conduct close-up activities such as cooking or maintaining things around the house (NEI, 2021).

Macular degeneration can be classified into two types: dry and wet. Dry macular degeneration is the most common type and usually progresses more slowly. Wet macular degeneration is less common, although it can result in significant visual loss. The specific cause of AMD is unknown; however, smoking, high blood pressure, being overweight, and having a family history of AMD have all been associated with AMD (NHS, 2021).

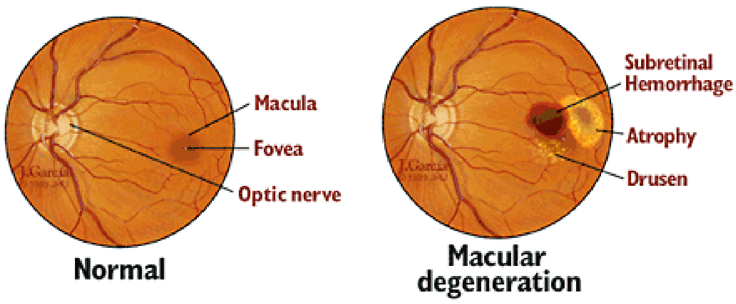


Figure 22. Diagram showing the comparison between a normal eye and one with macular degeneration (Johns Hopkins Medicine, 2023).

5.2.1 Possible Causes of Age-Related Macular Degeneration

Case 1

Matti is a young, healthy person who goes to the gym every day, eats healthy food, and does not smoke. However, Matti's family has a history of AMD and diabetes.

Case 2

Matti is an old, overweight, heavy smoker, and has hypertension. His diet only consists of bacon and McDonalds, and he has a BMI of more than 34 kg/m^2.

Case 3

Matti already has AMD in one eye; however, his diet is rich in omega-3 and -6, and he goes mountain biking every weekend.

Case 4

Matti was infected with COVID-19 in 2021 and now suffers from several post-COVID symptoms (Firoz & Talwar, 2022).

Based on the four cases provided, the AI now has 4 different scenarios to consider in order to optimize Matti's personalized treatment.

5.2.2 Solutions to Prevent or Slow the Progression of Age-Related Macular Degeneration

There is no treatment to cure AMD (NHS, 2021), but vision aids can help reduce the effect on one's life, along with injections and light therapy to prevent the vision from getting worse.

5.2.2.1 To treat dry Age-related Macular Degeneration

The Age-Related Eye Disease Studies (AREDS and AREDS2) found that a combination of vitamins and minerals might slow the progression of dry AMD. AREDS supplements include these ingredients:

Vitamin C, Vitamin E, Lutein, Zinc, Copper, and Zeaxanthin.

It is crucial to emphasize that the first version of the supplements (AERDS) contained the antioxidant beta-carotene, which increases the risk of lung cancer in smokers and former smokers. The antioxidants in the newer form are zeaxanthin and lutein.

5.2.2.2 To treat wet Age-related Macular Degeneration

Eye injections

Injections are given directly into the eyes.

- Includes anti-VEGF medicines like ranibizumab (Lucentis), aflibercept (Eylea) and brolucizumab (Beovu).
- Stops the vision from getting worse in ~90% of people.
- Improves vision in ~30% of people.
- Usually given every 1, 2 or 3 months for as long as necessary.
- Side effects include bleeding in the eye, feeling like there's something in the eye, and redness and irritation of the eye.

Light treatment

A light is shined at the back of the eyes to destroy the irregular blood vessels.

- Includes photodynamic therapy (PDT).
- May be recommended alongside eye injections if injections alone do not help.
- Usually needs to be repeated every few months.
- Side effects include temporary vision problems, and the eyes and skin being sensitive to light for a few days or weeks.

5.2.3 Side Effects and/or Risks of Age-related Macular Degeneration Treatments

Treatments for wet AMD carry some risk of complications (Cleveland Clinic, 2023), including (but not limited to):

Eye infection, retinal detachment, structural eye damage, faster onset of cataracts, and severe vision loss.

5.2.4 Cost to Treat Age-related Macular Degeneration

Individuals without health insurance commonly pay between $9.000 and $65.000 for a two-year course of therapy with drugs injected into the eye to suppress the formation of and leaking from additional blood vessels. According to Larsen's (2021) figures, a vial of Avastin costs approximately $1.200 for monthly injections over the two years generally required, while a vial of Lucentis costs approximately $48.000 for monthly injections over the two years generally needed.

In most situations, the cost of two years of Visudyne and photodynamic therapy treatments, which work similarly, can exceed $10.000. Patients with early-stage AMD may be able to postpone its progression by taking particular antioxidants and zinc, which cost anywhere between $15 and $30 for a three-month supply.

5.2.5 Personalized Treatment for Age-related Macular Degeneration

Analyzing data from imaging tests such as optical coherence tomography (OCT) and fundus photography is one method to apply ML for personalized treatment of AMD. These scans produce comprehensive images of the retina, allowing medical professionals to observe changes in the macula's structure over time. Doctors can spot small changes in the retina that are not visible to the human eye by analyzing these photos with ML algorithms. This will assist them in detecting AMD early and developing more effective treatment methods.

Another way to apply ML for personalized AMD treatment is to analyze genetic data. Certain genetic variants have been linked to an increased risk of getting AMD, and ML algorithms can be used to identify patients who are more likely to acquire AMD based on their genetic profile. This data can be utilized to create personalized treatment plans which target the exact genetic elements that are causing the patient's illness.

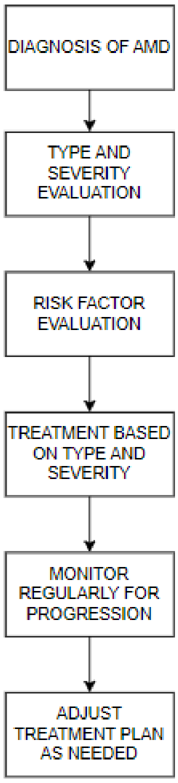


Figure 23. Visual representation of the algorithm flowchart for personalized treatment for AMD.

From a programming perspective, a recommendation system would be the most apt in this situation in order to get a personalized treatment. ML algorithms and techniques are used by recommendation systems to deliver the most relevant choices to specific users by reviewing data (which includes past behaviors) and predicting current interests and preferences. Content-based (for e.g., Netflix) and collaborative filtering are the two most common forms of personalized recommendation systems. Collaborative filtering provides appropriate recommendations based on user interactions with target objects. These recommender systems collect and analyze data from previous user behavior to identify which products to show to other active users with similar preferences.

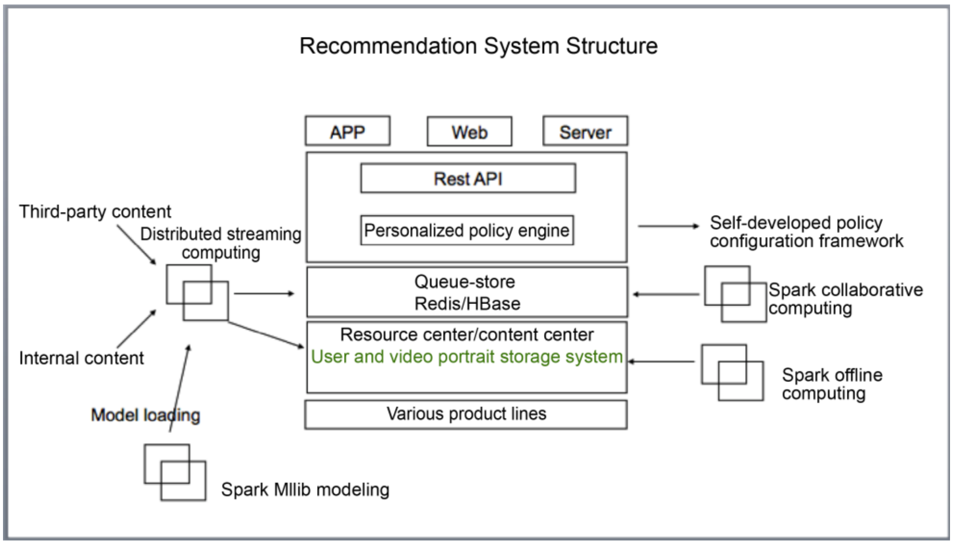


Figure 24. Recommendation system structure (Alibaba Cloud, 2017).

When it comes to ML, optimization is the process of finding the best possible values for the parameters of a ML algorithm or model that will minimize a certain objective function. This is done in order to find the best possible solution for Matti's diagnosis (or future diagnosis), since the goal of optimization is to find the set of parameter values that result in the best possible performance on the task at hand.

Gradient Descent, an optimization method for locating the local minima of a differentiable function, can be used to accomplish this. This minimization algorithm minimizes a given function.

$$f(\omega) = \sum_{i=1}^{n} \log\left(1 + \exp(-y_i \omega^T x_i)\right)$$

$$\frac{df}{d\omega} = \sum_{i=1}^{n} \frac{(-y_i x_i)\exp(-y_i \omega^T x_i)}{1 + \exp(-y_i \omega^T x_i)}$$

$$\omega_1 = \omega_0 - \gamma \left[\frac{df}{d\omega}\right]_{\omega_0}$$

$$\omega_1 = \omega_0 - \gamma \left[\sum_{i=1}^{n} \frac{(-y_i x_i)\exp(-y_i \omega^T x_i)}{1 + \exp(-y_i \omega^T x_i)}\right]$$

$$\omega_2 = \omega_1 - \gamma \left[\sum_{i=1}^{n} \frac{(-y_i x_i)\exp(-y_i \omega^T x_i)}{1 + \exp(-y_i \omega^T x_i)}\right]$$

and so on ...

$$\omega_i = \omega_{i-1} - \gamma \left[\sum_{i=1}^{n} \frac{(-y_i x_i)\exp(-y_i \omega^T x_i)}{1 + \exp(-y_i \omega^T x_i)}\right]$$

$$\omega^* = \underset{\omega}{\operatorname{argmin}} \sum_{i=1}^{n} \log\left(1 + \exp(-y_i \omega^T x_i)\right)$$

ω^* - optimal n-dimensional vector perpendicular to the plane that linearly separates +ve from -ve points.

n - number of data points

x_i - i^{th} data point

y_i - Ground truth of i^{th} data point

(1)

Figure 25. Gradient descent algorithm (Secherla, 2021).

The downside of this approach is that when the number of data points ‘n’ is large, it takes a lot of time for ‘k’ iterations to determine the optimal vector.

Another optimization strategy is to utilize Stochastic Gradient Descent (SGD), which is an optimization algorithm used in ML to decrease model error. SGD works by updating the model's parameters (weights and biases) in small increments based on the gradient of the loss function, which assesses how well the model performs on data. Mathematically, the SGD function can be represented as follows-

$$\omega_1 = \omega_{i-1} - \gamma \left[\sum_{i=1}^{m} \frac{(-y_i x_i) \exp(-y_i \omega^T x_i)}{1+\exp(-y_i \omega^T x_i)} \right]$$

$$where\ 1 < m < n \qquad (2)$$

$\mathrm{m} = \text{sample data collected from population n}$

SGD is the most important optimization algorithm in ML, and is mostly used in logistic and linear regressions (Secherla, 2021). Using SGD, the AI chooses one of the possible family history scenarios once it knows what kind of AMD Matti has (or will have) and chooses the best course of action— once it knows Matti's financial situation (can he afford the expensive medication if he does not have insurance), and if Matti is allergic to any of the drugs mentioned previously. Finally, the AI gives the most optimal solution to prevent (or reduce) Matti's AMD.

For instance, Matti is in his late 40s, suffers from post-COVID symptoms and is a heavy smoker. His family does not have a history of AMD but has a history of diabetes. The AI has predicted that Matti will develop AMD around his early to late 60s. While Matti cannot stop this, he is early enough to prevent this, and the AI gives him a personalized recommendation of how he should start bettering his lifestyle. Thus, he begins to take a diet rich in anti-oxidants and zinc, which does not cost him much.

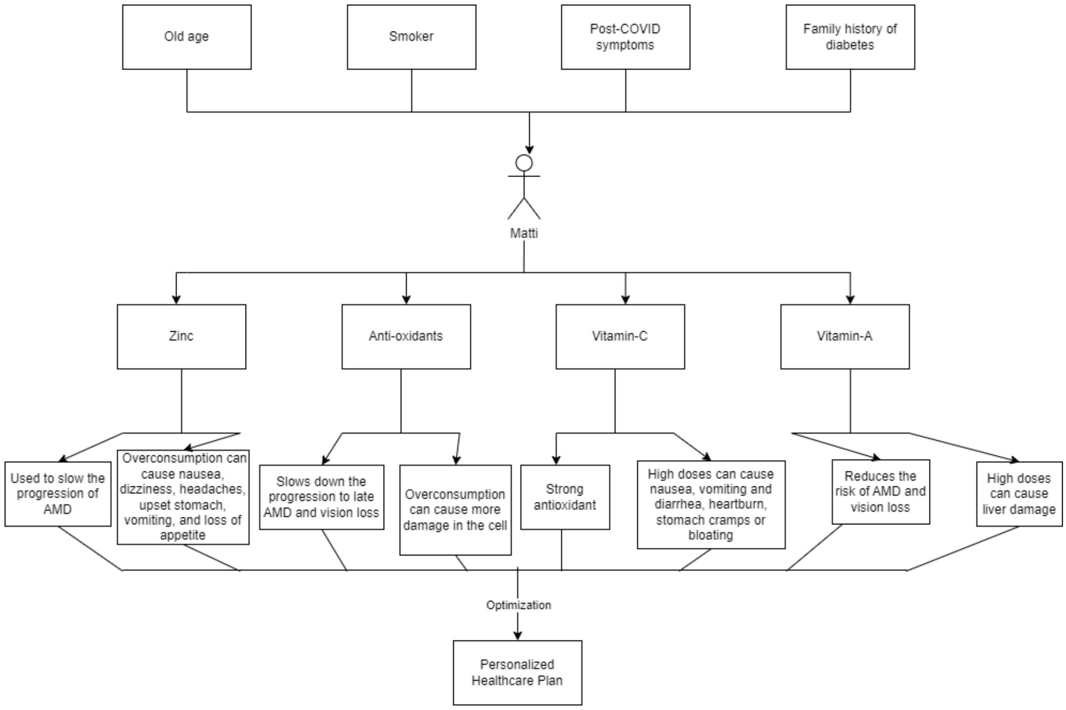


Figure 26. Visual representation of AI personalization.

Another scenario is this: Matti is in his 70s, and already has wet-AMD in one eye, since he was too late to detect it before it became worse. The AI has predicted that the likelihood of Matti getting AMD in his other eye is high, since his family has a history of AMD, despite Matti leading a clean and healthy lifestyle. Matti can slow down the AMD in his non-affected eye to simply make it a dry AMD, but for his infected eye, Matti has to get monthly injections. Based on Matti's genealogy, the AI has determined that Matti is allergic to the drug Avastin (which was later confirmed by doctors), and thus has to be treated by the drug Lucentis. It is not ideal, as that is the more expensive option, however it is the best option that the AI has personalized in order for Matti to have a reasonably good quality of life.

5.3 Why is Personalized Healthcare Necessary in 2023?

Personalized healthcare is necessary in 2023 for a number of reasons. For starters, it allows for a more customized approach to healthcare that takes a person's individual genetics, lifestyle, and environmental factors into account. Understanding a person's distinct needs and dangers allows healthcare providers to build more effective preventative and treatment plans that are tailored to the needs of their patients.

Second, personalized healthcare has the potential to improve patient outcomes while also lowering healthcare costs. Healthcare professionals can increase treatment effectiveness and lower the likelihood of adverse side effects by offering targeted treatments that are tailored to an individual's specific needs. This may result in improved health outcomes, fewer hospitalizations, and lower overall healthcare costs.

Finally, technological and data analytics advancements have made personalized healthcare more accessible and cheaper. Electronic health records and wearable devices, for instance, can give medical professionals with real-time data on an individual's health, making it easier to identify health hazards and deliver focused treatments.

6 CONCLUSION AND DISCUSSION

6.1 Ethics of Artificial Intelligence and Personalization

The ethics of AI and personalization are complex and multi-layered, and there is ongoing debate and discussion about the best ways to approach these issues (Russell & Norvig, 2019, 1035-1055; Xu et al., 2011; Alabi, Vartiainen, & Elmusrati, 2020). Some of the key ethical considerations related to AI and personalization include:

Privacy: Personalization often involves collecting and analyzing large amounts of personal data, which raises concerns about privacy. AI systems must be designed in a way that respects individuals' privacy rights, including their right to control their personal data and to know how it is being used.

Bias: AI systems can spread and even augment biases that exist in society, particularly if they are trained on biased data. Developers must work to eliminate bias from their AI models and ensure that they are fair and unbiased in their decision-making.

Autonomy: AI systems have the potential to influence people's behavior and decision-making in significant ways. It is important to consider the autonomy of individuals and ensure that they are not being manipulated or coerced by AI systems.

Accountability: There must be clear accountability mechanisms in place for AI systems, including mechanisms for identifying and addressing any errors or biases that may arise.

Transparency: AI systems must be transparent in their decision-making processes so that individuals can understand how decisions are being made and challenge them if necessary.

Consent: Personalization often requires individuals to consent to the use of their personal data. AI systems must ensure that individuals are fully informed about how their data will be used and have the opportunity to provide informed consent.

Human-centeredness: AI systems must be designed with the well-being and interests of humans in mind. This means taking into account factors such as social and environmental impact, and ethical considerations.

The ethics of ML in Spotify involve a range of considerations related to data privacy, bias, and accountability. As ML continues to play an increasingly important role in the music streaming service, it is essential that these ethical considerations are carefully considered and addressed to ensure that the service is both effective and ethical; a closer examination is necessary due to the substantial influence Spotify's recommendation algorithms have on the music and podcasting industries (Field, 2022).

Overall, it is crucial to approach AI and personalization ethics with a multidisciplinary and collaborative mindset, incorporating not only developers but also stakeholders from many sectors such as policymakers, ethicists, and affected communities. By doing so, scientists and programmers can ensure that AI and personalization are developed and deployed in a responsible, ethical, and sustainable way.

6.2 Results and Conclusion

ML has revolutionized personalization by allowing businesses to offer tailored experiences to their customers. With the vast amounts of data available, ML algorithms can analyze and make predictions about customer behavior, preferences, and needs. This enables businesses to personalize their products, services, and marketing messages to better meet the unique needs and interests of their customers. By using ML in personalization, businesses can increase customer satisfaction, loyalty, and ultimately drive revenue growth.

As ML continues to evolve and improve, it is likely that personalized experiences will become even more common and effective in the years to come. The examples from the above case study, and the results from numerous other studies done (Lin et al., 2017; Delanerolle et al., 2021; Wald, 2021), show just how beneficial healthcare personalization is—not just for the patient but also for doctors, hospitals, and other medical personnel.

With the rapid rate of advancement of AI (now with the release of GPT-4), one must take advantage of how to efficiently and ethically utilize ML methods in personalization to help ease the strain on the healthcare system and thus provide sufficient aid to the impoverished, down-trodden countries, and to those who cannot afford it. Thus, personalized healthcare is necessary because it provides a more personalized approach to healthcare, improves patient outcomes, and reduces healthcare costs, all while being more accessible and affordable than ever before thanks to advances in technology.

In conclusion, ML has revolutionized the field of personalization. By analyzing large amounts of data and using complex algorithms, ML can generate insights into users' behavior and preferences, allowing for highly personalized experiences that can improve engagement, satisfaction, and loyalty.

ML algorithms can be applied to various personalization use cases, such as product recommendations, content recommendations, email marketing, and personalized search results. In addition, ML can also help improve the accuracy and effectiveness of personalization by continuously learning from user interactions and adapting recommendations accordingly.

As technology continues to evolve, we can expect ML to play an increasingly important role in personalization, allowing businesses to create more relevant and engaging experiences for their users.

6.3 Further Discussion

Generative AI and Large Language Models (LLMs) have been rapidly evolving in recent years, and they have the potential to transform the field of medicine by enabling more personalized healthcare. Here are some specific examples illustrating how generative AI can be better than current AI techniques:

Drug discovery: Generative AI can be used to generate new drug molecules that are optimized for a specific target or disease. Unlike traditional drug discovery methods, which rely on trial and error, generative AI can generate thousands of candidate molecules in a matter of hours, greatly accelerating the drug discovery process.

Natural language processing: LLMs can analyze large volumes of clinical notes and other unstructured data to extract meaningful information about patient health status, treatments, and outcomes. This can provide clinicians with a more complete picture of a patient's medical history and help inform treatment decisions.

Medical imaging analysis: Generative AI can be used to generate high-resolution medical images that are used to train other AI algorithms. This can improve the accuracy and precision of medical image analysis, leading to better diagnoses and treatment plans.

Personalized risk assessment: Generative AI can analyze a patient's medical history and other factors to generate personalized risk assessments for various health conditions. This can help identify patients who are at high risk of developing certain conditions, enabling earlier interventions and better outcomes.

In general, generative AI and LLMs are more effective than current AI techniques because they are better able to learn from complex, unstructured data and generate new insights and solutions. These technologies can help healthcare providers provide more personalized, accurate, and effective care to patients, leading to better outcomes and improved patient satisfaction.

Despite the potential benefits of generative AI and LLMs in healthcare, there are also limitations and challenges that need to be addressed. One of the biggest challenges is ensuring that the data used to train these models is diverse and representative of the population as a whole. If the data used to train the models is biased or unrepresentative, the resulting models may also be biased and may not be effective in providing personalized healthcare.

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