DRIVES

Development and Research on Innovative Vocational Education Skills

U2 MACHINE LEARNING OVERVIEW

U2.E3 MACHINE LEARNING APPLICATIONS, USE CASES AND REAL-LIFE EXAMPLES

Machine Learning Engineer

January 2021, Version 1

Co-funded by the Erasmus+ Programme of the European Union

The Development and Research on Innovative Vocational Educational Skills project (DRIVES) is co-funded by the Erasmus+ Programme of the European Union under the agreement 591988-EPP-1-2017-1-CZ-EPPKA2-SSA-B. The European Commission support for the production of this publication does not constitute endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

LEARNING OBJECTIVES

The student is able to

MLE.U2.E3.PC1	Know the different application domains of machine learning.
MLE.U2.E3.PC2	Analyse and discuss several examples and applications of machine learning.
MLE.U2.E3.PC3	Recognize the growing importance of machine learning techniques in today's society.

MACHINE LEARNING APPLICATIONS

HEALTHCARE

ENTERTAINMENT

RETAIL

TRANSPORT

SOCIAL MEDIA

EDUCATION

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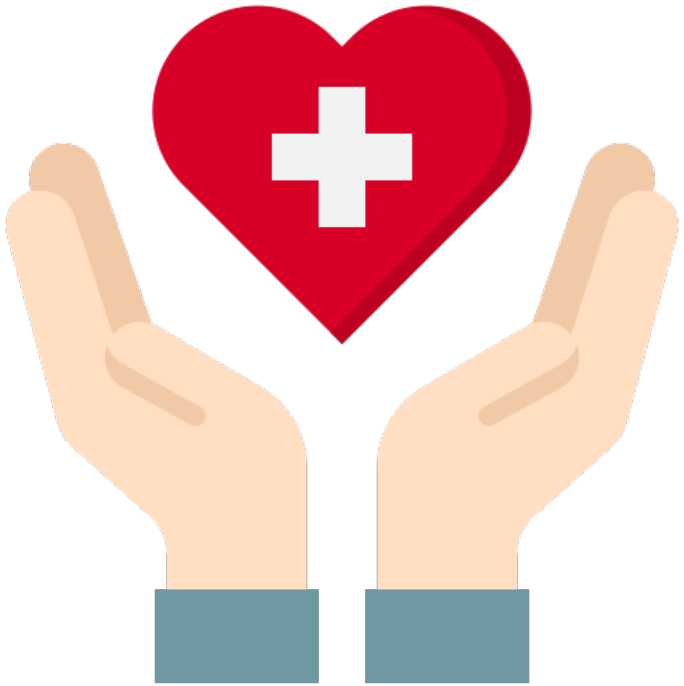
HEALTHCARE



Healthcare generates enormous amounts of data at a pace far surpassing what traditional methods of analysis can process. Machine Learning (ML) therefore has an endless potential in the health sector, as it is one of the best ways to integrate, analyze and make predictions based on large, heterogeneous data sets. ML can play a key role in supporting clinical decision-making and smart healthcare, enabling early identification of diseases, personalized medical treatment, outbreak prediction and better resource allocation, as well as streamlining hospital management processes and reducing administrative and supply costs.

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DRUG DISCOVERY AND MANUFACTURING

Development of new drugs is a time-consuming and costly process. Drug discovery and development pipelines are long, complex and depend on numerous factors.

Machine learning (ML) approaches provide a set of tools that allow the design of largely automated drug development pipelines. Integrating ML methods into drug development pipelines might also decrease drug development cost and time. In addition, systematic methods allow study replication and reusability, and enable standardized, transparent data quality control and sharing.

Examples: target validation, identification of prognostic biomarkers, analysis of digital pathology data in clinical trials, etc.

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TREATMENT AND PREDICTION OF DISEASES

ML has the ability to process huge amounts of data beyond the scope of human capacity, and to reliably convert the analysis of these data into clinical insights. It provides methods, techniques, and tools that can help solve diagnostic and prognostic problems in a variety of medical fields. ML is already being used to analyze the meaning of clinical parameters, such as symptoms, laboratory test results and patient's medical history, for disease prognosis, for the extraction of medical knowledge, for therapy planning and support, and for overall patient management, ultimately leading to better outcomes, lower healthcare costs, and increased patient satisfaction.

Examples: analysis of risk factors, identification of clinical conditions, disease progression, tailored treatment therapies, patient monitoring, intelligent alarming systems, etc.

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MEDICAL IMAGING

While today's medical images contain a wealth of information, the relevant information is hidden in the pixels or voxels and often not readily available. Machine learning models can be trained to look at images, identify abnormalities, and point to areas that need attention, thus improving the efficiency, reliability and accuracy of all these processes. ML can therefore be used to improve the efficiency of radiology practices. One concern is that, if these approaches are successful, the work of radiologists may become obsolete. This will never happen; instead, future radiologists will use ML as a collaborative partner that identifies specific areas of focus, illuminates noise, and helps to focus on high-probability areas of concern.

Examples: medical image processing, analysis and segmentation, PET-MRI attenuation correction, radiotherapy, lesion detection and segmentation, etc.

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ML PROJECTS IN HEALTHCARE

The use of machine learning within healthcare is still in its infancy, but there are several strong initiatives across the scientific community and multiple large companies pursuing healthcare projects based on machine learning.

These companies are not limited to medical technology enterprises, Google Brain, DeepMind, Microsoft, and IBM are examples of companies that also dedicate to the use of machine learning approaches to solve healthcare problems. There is also a plethora of small and medium-sized businesses in the field.

ML PROJECTS IN HEALTHCARE

https://www.kensci.com/

KenSci began as a project at the University of Washington, Tacoma, and is now a leader in addressing healthcare problems with AI through a team of some of the best physicians, developers and data scientists. KenSci's AI platform for healthcare solutions uses machine learning to help organizations improve health outcomes with advanced analytics.

https://www.cioxhealth.com/

Ciox is a health technology company dedicated to improving health information management and exchange of health information through the use of machine learning with the goal of modernizing workflows, facilitating access to clinical data and improving the accuracy and flow of health information.

ML PROJECTS IN HEALTHCARE

Microsoft

Microsoft's InnerEye Project uses ML to develop innovative tools for automatic, quantitative analysis of three-dimensional medical images to distinguish between tumors and healthy anatomy, to assist medical experts in radiotherapy and surgical planning, among other things.

https://www.microsoft.com/en-us/research/project/medical-image-analysis/

PathAI

PathAI is developing cutting-edge technology that promises to assist healthcare professionals in making rapid and accurate diagnosis as well as developing solutions to help identify patients that benefit from novel therapies, to make scalable personalized medicine a reality.

https://www.pathai.com/

ML PROJECTS IN HEALTHCARE

https://www.pfizer.com/

R&D is at the heart of Pfizer's goal of translating advanced science and technology into the most important therapies. Using Watson AI technology from IBM, Pfizer uses machine learning for immuno-oncology research on how the body's immune system can fight cancer.

https://prognoshealth.com/

Prognos' Health AI platform used machine learning to transform diagnostic and transactional data into insight-ready information that ultimately facilitates early disease detection, identifies therapy requirements, highlights clinical trial opportunities, notes gaps in care and other factors for a number of conditions.

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CHALLENGES AND OPPORTUNITIES

Machine learning approaches are more and more used in the health field and increasingly successful in image-based diagnostics, disease prognosis and risk assessment.

These challenges concern the application of machine learning methods for the diagnosis of rare diseases with limited data volumes, the improvement of data access in order to merge regional data into national datasets that allow the creation of stronger models, the use of metrics that are intuitive to clinicians and ideally go beyond measures of accuracy to include quality of care and patient outcomes, the reduction of brittleness and improvement of generalizability, the interpretation of results and their consequent application in clinical practice, among others.

RETAIL

Propelled by the growing technological advances and the consequences of the current COVID-19 pandemic, the number of online purchases is steadily increasing, allowing companies to gather detailed information on the entire customer experience. These data can then be used for a number of purposes, from improving user experience to make it easier, more efficient, more engaging and more tailored to personal needs, to inventory management and fraud protection. ML has opened up a new perspective on the optimisation of marketing and business processes in the retail sector and is a strong game changer in the reinvention and evolution of e-commerce and retail business.

DEMAND PREDICTION AND STOCK MANAGEMENT

Retail companies must ensure that the stock is in the correct quantity to meet the needs of consumers. Over-stocking or under-stocking of products is destructive to the retail business. Inventory management is therefore essential in order to maintain the right level of inventory to meet market demands. ML can make production and distribution more efficient by predicting demand for products according to seasonality, analyzing sales trends and anticipating changes in product demand. With this knowledge, ML can inform inventory managers the need for ordering or fabricating more products to maintain supply or upselling when products are overstocked.

Examples: prediction of market demands, analysis of product sale trends, anticipation of changes in product demand, costumer segmentation, etc.

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PRICE OPTIMIZATION

Another way for retailers to benefit from ML is through real-time and dynamic price adjustments. Instead of using static prices and cutting them down when KPI sales fall, commerce companies can benefit from ML-based price optimization algorithms to determine the best price point for products. Airline companies were among the first to adopt this approach. ML algorithms learn historical purchase data and find patterns to predict the best prices, suggest discounts, or up-sales when appropriate. ML can change and adjust prices taking into account different factors at the same time, such as competitor's pricing, product demand, seasonality, sales trends, market conditions, time of the day, and customer type. For example, when competing stocks are running low, it is an opportunity for the company to increase prices without losing sales.

Examples: predict the optimal price of a product, suggest discounts or up-sales, etc.

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FRAUD DETECTION

With the digital era in full growth, the risk of scam has now increased considerably. Retailers are particularly vulnerable to fraudulent activities such as the use of stolen credit cards, refund fraud, phishing or customers who withdraw payments through their credit card company once the goods have already been delivered. Hence, every time fraud occurs, the company loses money, trust, and customers, which are hard to refund. ML can be a helpful application in e-commerce when it comes to detecting and preventing any kind of fraud, ensuring cybersecurity. ML makes it possible to respond to threats in real time by immediately noticing a transaction that differs from the norm and signaling it as potentially fraudulent. A payment can be classified as suspicious if it comes from an unusual location or a different IP address, occurs on an unverified device, or happens at a strange time.

Examples: payment analysis, fraudulent activity detection, hacker attacks, etc.

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ML PROJECTS IN RETAIL

ML can be considered the great differential for e-commerce and retail companies. There are a number of ways in which the power of ML can unleash the full potential of commerce. ML helps e-commerce and retail companies take customer experience to a whole new level and generate revenue in ways that they have never been able to do before. Its impacts result in customer segmentation, personalization of services/products, targeted marketing campaigns, improved customer service, better managing and supply demand, churn prediction, price optimization and fraud detection.

Consequently, an increasing number of business brands are now relying on ML techniques for pushing business conversion, growth and customer engagement.

ML PROJECTS IN RETAIL

https://www.amazon.com/

As the world's leading retailer, Amazon has access to the largest volume of commercial consumer data, where ML is used to obtain accurate insights from these data for a variety of purposes. For example, the company uses ML on customer data to make accurate predictions for products, to detect fraudulent activities and to make customer-specific product recommendations.

https://www.alibaba.com/

Alibaba, China's business-to-business (B2B) e-commerce giant, serves millions of small retailers. After using Big Data Analytics for some years, Alibaba started using ML to analyze in-store customer behavior and find the most popular price points for products purchased by its retail customers.

ML PROJECTS IN RETAIL

https://www.walmart.com/

The Intelligent Retail Lab is a Walmart store equipped with cameras that offer information about the stock or condition of products as well as user's shopping behavior. This information is used by ML algorithms to map better delivery routes, provide faster check-out and make better recommendations and product matches based on the user's web browsing and purchase history. Walmart also uses ML to create and display specific advertisements to target consumers.

https://www.costco.com/

Costco retailer uses ML to maintain productivity and sustainability in their fresh food department, as it is costly to produce more fresh products than the ones necessary. Hence, Costco applies demand forecasting algorithms to help managers anticipate the demand for each fresh product that needs to be produced on a daily basis, along with the timing of restocks for peak hours.

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CHALLENGES AND OPPORTUNITIES

ML is transforming the e-commerce and retail industry. Evolving applications of ML in retail companies are being applied to numerous areas including costumer segmentation, supply and demand prediction, marketing, advertising, fraud detection, search optimization for increased sales, and personalization of product recommendations for increasing customer lifetime value and retention.

As competition and the need for efficiency continue to increase, the role of ML in online retail and e-commerce is only expected to grow in the future. The main challenge for the retail sector is that many retailers and small businesses are struggling to adopt technology and are unable to take advantage of ML's innovative offerings.

SOCIAL MEDIA

Social media has grown into a vast and hyper-dense digital environment with an astounding amount of information about preferences, activities, lifestyles, political affiliations, intentions, relationships, and basically everything around us. Hence, social media holds rich unknown information, but the challenge for any person or business to use social media as a scanable resource is complex, making it the perfect target for ML applications. The uses of ML in social media ranges from brand monitoring tools that gauge public opinion to efficient and automated advertising and protection against cyberbulliyng.

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ADVERTISING AND MARKETING STRATEGY

Many brands have taken advantage of the opportunity to use social media for marketing purposes. Nowadays, the leading social media platforms are also relevant marketing channels, often replacing traditional methods such as TV commercials or flyers.

Marketers have an unprecedented ability to run paid ads on social media platforms based on highly granular demographic and behavioral targeting, optimizing them for clicks and conversions.

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ADVERTISING AND MARKETING STRATEGY

Given the sheer volume of social media activity, it is impossible for a company, even with a dedicated social media team, to keep track of all brand references. Instead, ML-powered automated tools can help brands gain insight into the impact of their products/services, customer preferences, new ways customers use the product, and even new business opportunities. In addition, through clustering, customer segmentation techniques are now capable of creating user personas, enabling companies to reach a very personal level of targeted marketing.

Examples: prediction of market demands, analysis of product sale trends, anticipation of changes in product demand, costumer segmentation, etc.

SENTIMENT ANALYSIS

ML algorithms have been widely used for automatic sentiment analysis. Sentiment analysis regards the extraction of information from an unstructured source such as user generated text, images or audio in order to identify and classify opinions or sentiments expressed in the data. Social media generates a vast amount of sentiment rich data in the form of tweets, posts, status updates, etc. The automatic analysis of sentiments on data found in the World Wide Web is useful for any company or institution concerned with quality control. Instead of using traditional methods such as surveys, which are time-consuming and rely on the goodwill of costumers, being often associated with inaccurate results, companies can use sentiment analysis to understand the opinions of their customers. Customers who share their thoughts online tend to have more pronounced opinions than average, which additionally influence others to read them, leading to so-called word-of-mouth marketing. In addition, these opinions are extracted in real-time, enabling faster response times to market changes and detailed time-based statistics that allow trends to be plotted over time.

SENTIMENT ANALYSIS

The use of Social Media has increased enormously in recent years, and as a result, the possibility and growth of cyber threats have increased as well such as fraud, blackmail, spam, impersonation, and bullying. Bullying is a serious health issue among adolescents, where victims usually experience negative emotions such as depression and anxiety and, in extreme cases, even suicidal attempts. Sentiment analysis powered by ML techniques has the potential to detect early threats and to identify at-risk individuals as well as to enhance the scientific insight of bullying traces to understand participants' motivations and enforce potential interventions. This type of study can help social media managers detect the types of accounts that they need to remain alert in real time, creating a more secure social media experience and a healthier environment.

Examples: mitigation of hate speech and cyberbullying, analysis of a product/service satisfaction, understand brand reputation, online conversation monitoring, etc.

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ML PROJECTS IN SOCIAL MEDIA

ML is already doing exciting things with social networks, such as parsing data, optimizing ads, and syncing with e-commerce systems. Given the prevalent role that ML now plays in social media, its use is only expected to grow in the future. As technology develops, we're going to witness ML do incredible things in the social media world.

The role of ML in empowering social media is manifold. Proof of this is the fact that all famous social networks rely on ML techniques to improve their functioning and even compete with each other to be able to provide more personalized user experience and high levels of engagement.

ML PROJECTS IN SOCIAL MEDIA

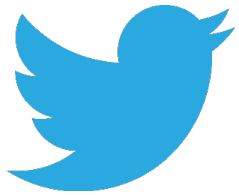
https://www.facebook.com/

Facebook uses ML to develop advanced algorithms that rank feeds and search results, create text-understanding algorithms (DeepText) that keep spam and misleading content away, and automatically capture videos in News Feed through speech-recognition systems. ML is also used to display billions of translated stories every day, to develop computer-vision algorithms that make images and videos accessible to the blind, and to create magical visual experiences such as turning panorama photos into interactive 360 images.

https://www.instagram.com/

ML is used by Instagram for a number of purposes, including target advertising for companies wanting to reach a specific customer profiles, the prevention of cyberbullying by automatically removing offensive posts and comments, the improvement of user experience by displaying a personalized feed instead of a reverse-chronological order and, the enhancement of the search engine, through tagging, which enables users to find photos for a specific activity, topic or event, or to discover the world's trendy experiences, restaurants and locations.

ML PROJECTS IN SOCIAL MEDIA



https://twitter.com/

Twitter is a social media platform used for social messaging, news reporting, event promotion, marketing and business. Cortex, Twitter's ML engineering team, employs ML to promote engagement, highlight the most relevant tweets on users' feeds, and promote healthier conversations by removing inappropriate stigma, racism and terrorism-related speech, fake news and illegal content.

TikTok

https://www.tiktok.com/

From lip-syncing and dancing videos to video memes, TikTok allows the creation of user-generated video content trends. Engagement has been so eager that TikTok creators have received worldwide recognition. The magic behind the app's unique obsession is its highly customized ML recommendation engine. The personalization algorithm takes into account user demographic data and past engagement, such as viewing time, saved videos, and trending hashtags and sounds, to determine which videos will be displayed on users' feeds.

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CHALLENGES AND OPPORTUNITIES

Undoubtedly, ML has been a fundamental resource for the advancement of social networks, creating new possibilities hitherto unnatainable. However, some issues and limitations still need to be addressed.

The biggest challenge facing ML in the social media industry is the issue of data collection and transparency due to the potential for unprotected digital privacy. More research should therefore be done to safeguard the ethics and privacy of users using ML-powered social media applications. There are also issues related to social and human cognitive bias due to the personal preferences, culture, education and beliefs of the researcher that may influence algorithmic development. In addition, the under-representation of minority classes, which may result in an algorithm that does not apply to or represent all cultures/minorities, must also be addressed.

ENTERTAINMENT

The entertainment industry is booming as artificial intelligence is unleashing an entirely new approach to creativity. The use of machine learning techniques in the entertainment industry is helping the media companies to improve their services and enhance the customer experience. Today, most of the entertainment companies adopt AI to focus on delivering high-quality content that grabs the attention of public. The applications of ML in the entertainment and media (E&M) industry include marketing, advertising, user experience personalization, search optimization and content production.

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PERSONALIZATION OF USER EXPERIENCE

The entertainment and media (E&M) industry is witnessing a rapid transformation in the way content is distributed. The growing ubiquity of content creation tools such as high-resolution cameras, content creation software, and smartphones enables individuals to create, publish, and distribute written, audio, and video content. So, in terms of media consumption, consumers have potentially limitless options to choose from.

Entertainment companies are faced with the need to increase both the quantity and the quality of the content they create in order to gain competitive advantage and to attract as many consumers as possible. These companies must therefore give increasing priority to user experience. ML is one of the leading technologies capable of making a positive contribution to this effort.

PERSONALIZATION OF USER EXPERIENCE

Hence, in the entertainment field, the personalization of the user experience is shifting from an additional benefit to a standard consumer expectation, and as a result, ML is now a decisive strategy for keeping pace with consumer demand. Entertainment providers are currently using ML to study individual user behavior and offer personalized content recommendations to each client based on demographic data, user's preferences, search history, past activity, history of purchases/services, among others. In this way, media companies are able to retain consumers in their services by constantly engaging them and providing them with highly personalized experiences.

Examples: personalized experiences through automatic similarity analysis and recommendation, advanced playlists generation, etc.

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METADATA TAGGING AND SEARCH OPTIMIZATION

In terms of media consumption, there are potentially limitless options to choose from. With the wide range of content available, classifying these items and making them easy to search for users becomes a complex and time-consuming task, as it involves watching/listening content and identifying different aspects in the video, such as objects, scenes, and locations, to classify them and assign them tags. ML techniques become in handy to perform this task on a large scale through the training of algorithms that analyze content frame by frame to identify specific characteristics and assign appropriate tags, which can then be organized and catalogued to deliver robust search results. Entertainment companies are therefore using ML tools to improve the speed and efficiency of the media production process and the ability to organize visual assets. As a result, regardless of its volume, all content held by media companies is easily recognizable.

Examples: automatic music, film or game tagging based on high-level descriptors, etc.

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ML PROJECTS IN ENTERTAINMENT

Machine learning and advanced analytical capabilities of artificial intelligence hold the power to directly influence marketing strategies for the promotion of products or services. ML techniques help to identify the content that is most widely accepted by users and to determine which type of content can drive more earnings. Hence, simplifying and optimizing the work of media companies in terms of identifying and creating business plans to drive revenue based on your customers experiences.

As a result, today, most media and entertainment companies rely on ML algorithms to organize and improve their content, offer suggestions tailored to each consumer's preferences, create new, enjoyable and profitable content, and ultimately keep users constantly engaged.

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ML PROJECTS IN ENTERTAINMENT

NETFLIX

https://www.netflix.com/

As the world's leading Internet television network, Netflix members consume hundreds of millions of hours of content per day, so predicting what users want to watch is a key part of the company. Netflix uses ML algorithms to offer personalized recommendations, to help shape the catalog of movies and TV shows by learning characteristics that make content successful, to optimize video and audio encoding, to powers advertising, among others.

Spotify®

https://www.spotify.com/

Nowadays, there is an enormous amount of music that challenges individuals to discover music they like, or even new songs. Spotify is the world's largest music streaming service and uses ML algorithms to create machine-generated personalized playlists such as Discover Weekly and Release Radar. Spotify uses three types of ML to enhance its recommendation engine: collaborative filtering, natural language processing, and raw audio models.

ML PROJECTS IN ENTERTAINMENT

YouTube

https://www.youtube.com/

The entertainment sector is increasingly concerned with making their content useful to audiences from different regions, which naturally depend on accurate multilingual subtitles. Youtube uses speech recognition algorithms to automatically create video captions. ML is also used to identify the content of the video and to assign it search keywords to provide users with better search results, as well as to recommend videos and to automatically generate playlists of songs.

BEAT SABER

https://beatsaber.com/

Beat Saber is a music-rhythm dance game that takes advantage of what virtual reality has to offer to slash blocks in particular directions, avoid bombs, duck obstacles, etc. It is an intuitive, physically challenging, and almost unbelievably cool-feeling rhythm game.

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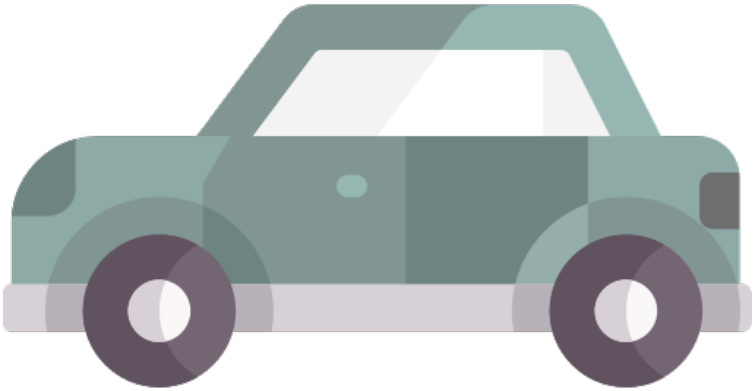
CHALLENGES AND OPPORTUNITIES

ML is transforming the media and entertainment industry. Today, ML algorithms play a major role in improving the efficiency and quality of the content produced in the entertainment world as well as in providing media companies with competitive advantage and profitable solutions. Emerging applications of ML in the media industry are being applied to multiple areas including marketing, advertising, search optimization, personalization of user experience and content production. Innovations in these areas, will save industry professionals time and improve the efficiency of the production process.

As competition and the need for efficiency continue to rise in the industry, the role of ML in entertainment is only expected to grow in the future. However, entertainment powered by ML technology faces the challenges related with data collection and transparency due to privacy issues of consumers. More research should therefore be done to secure private data.

TRANSPORT



The availability of increased computational power and the collection of massive amounts of data propelled by the digital age have redefined the value of ML-based approaches to address emerging demands and needs in transport systems. As a result, ML perspectives are being used to understand travel behavior and address important transportation challenges particularly in terms of traffic management, travel time, congestion relief, traffic safety, public transport, CO2 emissions and environmental degradation.These challenges arise from the continuous growth of rural and urban traffic, due to the increasing number of individuals, particularly in developing countries.

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TRAFFIC AND ROAD OPTIMIZATION

The number of vehicles is increasing, leading to more congested and dangerous roads. The creation of more roads alone will not solve the problem as the construction cost is very high and the time required to obtain results is too long to catch up with the vehicle increase rate. At the same time, the growing availability of data in transportation systems has become a bottleneck for traditional data analytics solutions.

One way to improve fleet management is through ML, a data-driven solution that can cope with the new requirements.

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TRAFFIC AND ROAD OPTIMIZATION

ML can extract important patterns in the data, such as real-time traffic flow and driver behavior under different traffic flow conditions, providing a way for real-time decision support on which route the user should take to get faster to the desired location, as well as enabling a better incident management, helping emergency teams save lives and reduce incident recovery time. In this way, ML can significantly improve the efficiency of existing transport system operations and predict future trends.

Examples: automatic suggestion of the fastest or shortest route, efficient incident management enabling prompt assistance, etc.

SELF DRIVING VEHICLES

Self-driving vehicles have appeared as a way of making roads safer as they can make better and more reliable decisions than human minds. ML algorithms allow self-driving vehicles to learn and adapt to the unpredictable behavior of other vehicles and even humans or animals in the surrounding environment, enabling them to make judgments in real time. The self-driving vehicle is equipped with a variety of sensors that collect data to feed ML algorithms in order to make driving decisions based on immediate surroundings and past experience in order to provide passengers with safe and efficient travel experience. ML can be used to monitor the driver through facial recognition algorithms, to learn and detect signs of fatigue or lack of attention, and to act accordingly by warning the other occupants or by slowing down or stopping the vehicle, in the event that this does not result in further harm. In addition, it can help identify the driver and verify if he or she has permission to drive the car, which could help prevent unauthorized use and theft.

SELF DRIVING VEHICLES

As a result, ML can perform safety maneuvers faster than the driver can react and could potentially perform complex and subsequent movements that a human being could not perform to avoid a collision, which increases safety and confidence in autonomous cars. Although fully autonomous vehicles are only used for prototyping and testing, ML has already been applied in advanced driver assistance systems. In fact, powered by ML algorithms, there are already vehicles on the market that can detect their surroundings and park themselves without driver input, allowing tighter parking spots to be used.

Examples: detection and classification of objects/animals/humans, avoid distraction accidents, efficient incident management enabling prompt assistance, etc.

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ML PROJECTS IN TRANSPORT

Researchers are focusing on improving existing Intelligent Transportation Systems (ITS) applications and developing new ones. ML already has a significant impact on transport systems, to the point that nowadays all manufacturing companies are using ML techniques to improve vehicle efficiency and safety as well as to provide personalized user-experience to passengers.

The underlying goals for these solutions are to reduce congestion, improve safety, reduce human errors, mitigate adverse environmental impacts, optimize energy performance, and improve productivity and efficiency of transportation.

ML PROJECTS IN TRANSPORT

Uber

https://www.uber.com/

Uber's decision-making is entirely data-driven with ML at its core. Michelangelo, Uber's ML platform, enables teams across the company to train, evaluate and deploy models that help them predict a wide range of business metrics and enhance their customer experience. ML helps Uber make data-driven decisions that include not only ride-sharing, but also financial planning and other core business needs.

WAYMO

https://waymo.com/

Waymo is the offshoot of the Google Autonomous Vehicle Project. Its goal is to create cars that can drive on their own without a human pilot. Waymo's cars use ML to see their surroundings, make sense of them, and predict how others will behave. With so many shifting variables on the road, an advanced machine learning system is crucial to success.

CHALLENGES AND OPPORTUNITIES

Given the availability of vast amounts of quantitative and qualitative data in this digital age, the use of ML techniques has made it more plausible to address transport concerns in a more efficient and effective manner. The aim of ML applications in the transport sector is to overcome various challenges, such as the increasing demand for travel, CO2 emissions, safety concerns and environmental degradation.

The main objective of the transport sector is the development of safe and efficient autonomous vehicles. However, in order to ensure the safety and security of autonomous vehicles, countries will need to have appropriate infrastructure in place and the legislative authorities will have a duty to legislate and regulate such vehicles in order to ensure that ethical and privacy considerations are taken into account.

EDUCATION

ML has become a new strength for higher education, and it is fundamentally changing teaching, learning, and research. ML brings numerous advantages to the table, including the fact that learning is easier, more efficient and customizable to the needs of each student, the reach and impact of online learning content is increased, the time spent by teachers in learning activities is reduced, and a fairer and less biased evaluation system can be put in place. This approach contrasts with traditional education, where everyone in the classroom is taught in the same way. As a result, stakeholders are embracing this unprecedented benefit, as it makes learning easier and more appealing.

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TEACHING

Education has always been largely focused on providing information to students and hoping that they will retain it. The problem with this approach is that it ignores how well students understand the information and how they apply it in real-life scenarios. Nowadays, education is not limited to the teaching and reading of textbooks or to students having to memorize manuscripts. The learning process, both inside and outside the classroom, has become an activity with objectives and measurable outcomes.

In recent years, schools, universities and other centers of education have therefore begun to realize how the use of machine learning can ease teaching and learning processes and make them more efficient.

TEACHING

The uses of Machine Learning in education are broad and work in harmony with students' needs, and at a time and place that suits them best. ML techniques have the ability to serve all students, regardless of their speed of learning, ensuring that no student is ignored or left behind. By using algorithms that learn how students consume information, ML allows them to move forward only after truly understanding the previous content. In addition, ML can provide a variety of learning options and also allow teachers to monitor and assist students individually in areas of greatest difficulty. Another contribution of ML is its ability to increase the efficiency and fairness of the grading system, such as plagiarism detection, as well as to reduce the time needed for grading.

Examples: personalized learning experience, forecast enrolment, identification of at-risk students and target interventions, development of a more efficient and accurate grading system, prediction of career paths, etc.

RESEARCH

Research in any scientific field has become more challenging than ever. Especially with the covid-19 pandemic, researchers are under immense pressure to bring exceptional breakthroughs for the future. ML will play an important role when it comes to shaping the future of innovation and R&D. Currently, the use of ML techniques is predominantly used in the chemistry domain, more specifically in the development and assessment of new drugs and medications. However, ML is expected to be decisive in many scientific areas as a large part of innovation and R&D involves the forecasting of different data-based variables and, with ML, classification and regression can be carried out in a faster and less costly manner through its ability to support cost optimization and improve performance across R&D where these tasks pose obstacles.

Examples: improve R&D efficiency and reproducibility, simplification of complex and tedious tasks, improve organizational operations, etc.

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ML PROJECTS IN EDUCATION

ML can potentially redefine not only how education is delivered, but also foster quality learning on the students' part. This technology relies on a broad spectrum of variables, such as individual student aptitude, learning speed, background, and response, to process the data in real time and provide feedback to the teacher, so he/she can recognize flagging students attention or poor response immediately and take corrective actions.

As a result, stakeholders are embracing this unprecedented benefit, as it makes learning easier and more appealing.

ML PROJECTS IN EDUCATION

BRAINLY

https://brainly.com/

Brainly is an education technology company that provides a peer-to-peer learning platform for students, parents, and teachers to ask and answer homework questions across different subjects such as English, mathematics, science, and social studies. The platform has elements of gamification in the form of motivational points and ranks and encourages users to engage in the online community by answering other users' questions.

duolingo

https://en.duolingo.com/

Duolingo is a language learning website and a mobile app that can be accessed free of charge, although Duolingo also offers a premium service for a fee. Duolingo mimics the structure of video games in a number of ways in order to engage its users, for example, it features a reward system in which users get "lingots", a currency that they can spend on features such as character customizations or bonus levels.

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ML PROJECTS IN EDUCATION

todoist

https://todoist.com/

Todoist is a top-ranked task management application that helps users to manage their personal and professional productivity using a smartphone, a tablet, or a computer. The application allows users to plan their day for maximum focus, to visualize productivity trends, to organize different projects as in-depth as the user desires.

GoodNotes

https://www.goodnotes.com/

GoodNotes is a note-taking application that helps users live a paperless life by allowing them to take handwritten notes in digital notebooks and annotate imported PDF documents. The digital notes are searchable due to handwriting recognition and OCR technology. All notes can be neatly organized in GoodNotes and users can automatically back up files to Dropbox, OneDrive, or Google Drive so that they never lose any file again.

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CHALLENGES AND OPPORTUNITIES

The innovations brought by AI and Machine Learning to Education have opened incredible possibilities. However, since AI-based education technologies are somewhat recent, there are a number of obstacles and limitations to consider.

The biggest challenge of education powered by machine learning technology remains the issue of data collection and transparency due to the potential of having unprotected digital privacy. More research should therefore be done to secure private data for both students and teachers, as well as researchers using Machine Learning devices.

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- Machine Learning has a wide range of applications in today's society from entertainment, social media, and retail to more decisive fields such as medicine, education, and transportation.

- Although there is already a wide variety of implementations, there is still a vast window of opportunity for Machine Learning in almost all areas of human life, in particular, it is important to emphasize its importance and to explore its role in the transport sector, where autonomous cars are the primary challenge and the ultimate goal.

REFERENCES

Vamathevan, J., Clark, D., Czodrowski, P., Dunham, I., Ferran, E., Lee, G., ... & Zhao, S. (2019). Applications of machine learning in drug discovery and development. *Nature Reviews Drug Discovery*, *18*(6), 463-477. https://doi.org/10.1038/s41573-019-0024-5.

Réda, C., Kaufmann, E., & Delahaye-Duriez, A. (2020). Machine learning applications in drug development. *Computational and Structural Biotechnology Journal*, *18*, 241-252. https://doi.org/10.1016/j.csbj.2019.12.006.

Patel, L., Shukla, T., Huang, X., Ussery, D. W., & Wang, S. (2020). Machine Learning Methods in Drug Discovery. *Molecules*, *25*(22), 5277. https://doi.org/10.3390/molecules25225277.

De Bruijne, M. (2016). Machine learning approaches in medical image analysis: From detection to diagnosis. https://doi.org/10.1016/j.media.2016.06.032.

Lundervold, A. S., & Lundervold, A. (2019). An overview of deep learning in medical imaging focusing on MRI. *Zeitschrift für Medizinische Physik*, *29*(2), 102-127. https://doi.org/10.1016/j.zemedi.2018.11.002.

Kelly, C. J., Karthikesalingam, A., Suleyman, M., Corrado, G., & King, D. (2019). Key challenges for delivering clinical impact with artificial intelligence. *BMC medicine*, *17*(1), 195. https://doi.org/10.1186/s12916-019-1426-2.

Asthana, P., & Hazela, B. (2020). Applications of Machine Learning in Improving Learning Environment. In *Multimedia Big Data Computing for IoT Applications* (pp. 417-433). Springer, Singapore. https://doi.org/10.1007/978-981-13-8759-3_16.

Nafea, I. T. (2018). Machine Learning in Educational Technology. *Machine Learning-Advanced Techniques and Emerging Applications*, 175-183. https://doi.org/10.5772/intechopen.72906.

REFERENCES

Ciolacu, M., Tehrani, A. F., Beer, R., & Popp, H. (2017, October). Education 4.0—Fostering student's performance with machine learning methods. In *2017 IEEE 23rd International Symposium for Design and Technology in Electronic Packaging (SIITME)* (pp. 438-443). IEEE. https://doi.org/10.1109/SIITME.2017.8259941.

El Naqa, I., & Murphy, M. J. (2015). What is machine learning?. In *Machine Learning in Radiation Oncology* (pp. 3-11). Springer, Cham. https://doi.org/10.1007/978-3-319-18305-3_1.

Gong, Y., & Xu, W. (2007). *Machine learning for multimedia content analysis* (Vol. 30). Springer Science & Business Media.

Yoganarasimhan, H. (2020). Search personalization using machine learning. *Management Science*, *66*(3), 1045-1070. https://doi.org/10.1287/mnsc.2018.3255.

Amat, F., Chandrashekar, A., Jebara, T., & Basilico, J. (2018, September). Artwork personalization at Netflix. In *Proceedings of the 12th ACM conference on recommender systems* (pp. 487-488). https://doi.org/10.1145/3240323.3241729.

Oliver, J. R. (1996). A machine-learning approach to automated negotiation and prospects for electronic commerce. *Journal of management information systems*, *13*(3), 83-112. https://doi.org/10.1080/07421222.1996.11518135.

Rath, M. (2020). Machine Learning and Its Use in E-Commerce and E-Business. In *Handbook of Research on Applications and Implementations of Machine Learning Techniques* (pp. 111-127). IGI Global. https://doi.org/10.4018/978-1-5225-9902-9.ch007.

Rao, H. K., Zeng, Z., & Liu, A. P. (2018, May). Research on personalized referral service and big data mining for e-commerce with machine learning. In *2018 4th International Conference on Computer and Technology Applications (ICCTA)* (pp. 35-38). IEEE. https://doi.org/10.1109/CATA.2018.8398652.

REFERENCES

Agarwal, B., & Mittal, N. (2016). Machine learning approach for sentiment analysis. In *Prominent feature extraction for sentiment analysis* (pp. 21-45). Springer, Cham. https://doi.org/10.1007/978-3-319-25343-5_3.

Boiy, E., & Moens, M. F. (2009). A machine learning approach to sentiment analysis in multilingual Web texts. *Information retrieval*, *12*(5), 526-558. https://doi.org/10.1007/s10791-008-9070-z.

Nahar, V., Unankard, S., Li, X., & Pang, C. (2012, April). Sentiment analysis for effective detection of cyber bullying. In *Asia-Pacific Web Conference* (pp. 767-774). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-29253-8_75.

Xu, J. M., Zhu, X., & Bellmore, A. (2012, August). Fast learning for sentiment analysis on bullying. In *Proceedings of the First International Workshop on Issues of Sentiment Discovery and Opinion Mining* (pp. 1-6). https://doi.org/10.1145/2346676.2346686.

Sintaha, M., Satter, S. B., Zawad, N., Swarnaker, C., & Hassan, A. (2016). *Cyberbullying detection using sentiment analysis in social media* (Doctoral dissertation, BRAC University).

Lanfranchi, V. (2017, May). Machine Learning and Social Media in Crisis Management: Agility vs Ethics. In *Proceedings of the 14th International Conference on Information Systems for Crisis Response and Management*. IMT Mines Albi-Carmaux (École Mines-Télécom).

Bhavsar, P., Safro, I., Bouaynaya, N., Polikar, R., & Dera, D. (2017). Machine learning in transportation data analytics. In *Data analytics for intelligent transportation systems* (pp. 283-307). Elsevier. https://doi.org/10.1016/B978-0-12-809715-1.00012-2.

Tizghadam, A., Khazaei, H., Moghaddam, M. H., & Hassan, Y. (2019). Machine Learning in Transportation.

Abduljabbar, R., Dia, H., Liyanage, S., & Bagloee, S. A. (2019). Applications of artificial intelligence in transport: An overview. Sustainability, 11(1), 189.

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This Training Material has been certified according to the rules of **ECQA – European Certification and Qualification Association.**

The Training Material was developed within the international job role committee **"Machine Learning Engineer":**

UMINHO – University of Minho (https://www.uminho.pt/PT)

The development of the training material was partly funded by the EU under Blueprint Project DRIVES.

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Thank you for your attention

DRIVES project is project under **The Blueprint for Sectoral Cooperation on Skills in Automotive Sector**, as part of New Skills Agenda.

The aim of the Blueprint is **to support an overall sectoral strategy and to develop concrete actions to address short and medium term skills needs.**

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Co-funded by the Erasmus+ Programme of the European Union

The Development and Research on Innovative Vocational Educational Skills project (DRIVES) is co-funded by the Erasmus+ Programme of the European Union under the agreement 591988-EPP-1-2017-1-CZ-EPPKA2-SSA-B. The European Commission support for the production of this publication does not constitute endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.