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Review

Predicting the Income Groups and Number of Immigrants by Using Machine Learning

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ABSTRACT

One of the most significant challenges that humanity has ever faced is migration. Urban planning, commerce, disease transmission, pandemics, and public policy are just a few of the many areas that rely on precise predictions of human movement. An increasingly ubiquitous tool, Artificial Intelligence (AI) allows us to forecast migratory patterns. The goal of this research is to use ML algorithms to foretell immigration numbers and income brackets. The research included two separate applications. Two separate projects were undertaken with the aim of forecasting immigrant income brackets and total numbers. This research made use of data collected by the World Bank. Initially, the research used SVMs, NBs, LRs, and KNNs (K-Nearest Neighbors) in its application. The study's second application made use of the Xgboost and Random Forest (RF) algorithms. Xgboost achieved a success rate of 98.37%, RF 96.42%, LR 86.04%, SVM 83.72%, KNN 83.72%, and NB 69.76% according to the study's data. With the LR and Xgboost algorithms, the research found that the applications were the most successful. Generally speaking, the human migration prediction machine learning models used in this research will provide a versatile foundation for modeling human migration in various what-if scenarios.

Keywords

Artificial intelligence (AI); Machine learning (ML); Migration; Data science.

INTRODUCTION

Regardless of the length, kind, or reason, migration is always characterized by a change in population that forces some people to leave their homes. Many factors, including conflicts, climate, displacement, natural catastrophes, and economic, political, and policy considerations, have prompted human migration throughout history. It is a well-known reality that people and groups relocate from their current locations for a variety of reasons. Individuals relocate for a variety of reasons, such as economic opportunity, family reunion, or refugee status, all fall under the umbrella term "migration" [1-2]. When a person moves with the purpose of relocating to a new location, this is called human migration. All human migrations, regardless of length, make-up, or origin, are collectively referred to as the migratory phenomena.

2.For those interested in AI, machine learning (ML) is one of the many subfields. Machine learning (ML) is an automated method for finding hidden structures (patterns) in data [3]. Machine learning (ML) techniques may model an existing issue and use a data set and computer algorithms to make predictions about the future. The purpose of machine learning (ML) models built using datasets and algorithms is to maximize performance. The precise migratory numbers of prospective nations may be calculated and studied with the use of models generated by ML algorithms [4]. According to [5], it was detailed the use of ML to the modeling of migration processes; the study's decision tree approach was employed. Their estimate was 67% accurate.

Migrating occurs in almost every facet of modern life, and in this information age, it is feasible to apply AI to provide a variety of migration forecasts. For nations concerned about migration, for instance, it would be helpful to forecast immigration numbers, income brackets, and other data using AI tools and approaches. The social, cultural, economic, and security aspects of this dilemma may be better anticipated and addressed if nations have access to or are able to predict information on immigration. Policymakers in the fields of strategy, planning, and industry rely on migration forecasts as a tool for gauging future population growth and size [6]. Countries and regional or international organizations that are aware of the correla-

tion between immigration numbers and income levels might use ML models to better anticipate and prepare for the arrival of newcomers.

Predicting immigrant income categories and numbers via categorization using various ML algorithms is the goal of this work, which is motivated by applying AI concepts and methodologies to the migration problem. This research included the execution of two distinct apps. Predicting the income brackets of immigrants was the primary focus of the initial application. Neural Networks, Support Vector Machines (SVMs), and methods such as K-Nearest Neighbors (KNN), Logistic Regression (LR), and (NB). Predicting the influx of newcomers was the focus of the study's second practical application. This application made use of the Xgboost and Random Forest (RF) algorithms. Its stated goal in both uses was to evaluate various ML algorithms for the purpose of predicting human migration. The research made use of two unique datasets, one of which was generated specifically for the purpose of this study; the other dataset included data from the World Bank in 2010. The research included a total of twenty-one separate trials.

Here are the key findings from this study:

• One significant addition of this work is the use of AI to estimate the income categories and total number of immigrants. Using Xgboost, RF ML, SVM, NB, LR, and KNN, several tests were carried out. We want to demonstrate, in a nutshell, that the migration problem—one of the most pressing issues in human history—can be addressed using AI techniques and methodologies.

• This research makes a new contribution by being the first to utilize two distinct data sets.

The topic continues with a literature analysis of relevant research in Section 2. In Section 3, we learn about ML algorithms and migration. In Section 4, the experimental investigations that comprised this investigation are detailed. Section 6 provides a conclusion to the study and explains some recommendations for further research.

II. RELATED WORK

Big data, autonomous systems, handwritten character recognition, natural language processing, image processing, convolutional neural networks, classification studies, and many more subjects have been researched in the literature utilizing AI and ML methodologies. Numerous studies and investigations on AI and ML can be found in the literature, and this trend is only expected to accelerate. Reasons for this include the pervasiveness of AI and its growing appeal in solving critical problems across all sectors of society. However, research on migration and AI constituted the bulk of the literature analyzed for this study. In a post-COVID international setting, the effects of growing digitization and AI on mobility and migration systems were analysed in [7]. Despite initial emphasis on the pre-departure and arrival phase, the authors stressed that AI progresses during the migration cycle. More than 6,281 Mexican immigrants' estimated legal status in the US was estimated using several ML approaches and a collection of pre-immigration characteristics in [8]. Eighty percent of Mexican immigrants to the US had their legal status anticipated, according to the report. The study by Beduschi in [9] tested the hypothesis that artificial intelligence (AI) could impact three areas of international migration management: (1) by exacerbating existing international asymmetries; (2) by updating long-standing policies and procedures of states and international organizations; and (3) by bolstering the present demand for border and migration management based on evidence. This paper delves into each of these three theories and highlights the main obstacles to using AI solutions for managing international migration. These research issues were addressed by the writers in [10]: 1. How can immigrants, their workers, and stakeholders in labor integration use artificial intelligence? 2. How might AI make immigrants' jobs better? skills? 3. How might AI interventions that promote inclusion and integration be successful? In order to forecast the arrival-origin flows of human migration, the authors of [11] suggested ML models that might include a variety of external variables. When it came to forecasting both domestic and international migrations, their models fared better than more conventional human mobility models that were tested using a battery of assessment criteria. Machine learning (ML) techniques formed the basis of the model given in [12]. These techniques are essential for building a reliable self-learning system that can describe the economic and social actions of a reasonable person who chooses to move in quest of employment. Using six agriculture-dependent economies—including Burkina Faso, Côte d'Ivoire, Mali, Mauritania, Niger, and Senegal—a tree-based ML technique was suggested in [13] to examine the impact of air shocks on people's intentions to migrate. The authors discovered that (i) a country-specific model was necessary, (ii) weather characteristics improved prediction performance, and (iii) the longer time scales of SPEIs had a stronger influence on international moves than general moves (including internal moves), even though socioeconomic characteristics had a larger impact on migration intentions. A number of measurable criteria may be used to forecast the movement patterns of internally displaced persons (IDPs), according to Harrison's research reported in [14]. These results also suggest that ML approaches may be very useful in addressing the requirements of vulnerable people, identifying new ways to help those in need, and designing more efficient migration routes.

According to the reviewed literature, AI is being employed in several fields, including the migration problem, due to its growing interest. Additionally, the literature research reveals that there is a growing trend of AI applications related to migration.

III. MIGRATION AS A GLOBAL PHENOMENON

Worldwide, migration has been a major issue for ages [15]. The current levels of migration and dislocation are unparalleled in history [16–17]. It has been noted that human societies and individuals have moved for many reasons, including social, cultural, political, economic, and security concerns, throughout history and even in the present day. The most well-known social crises that generate migration are war and hunger. Any kind of movement, seasonal or otherwise, is mostly driven by economic considerations [18]. Uncertainty in the job market and high unemployment rates are associated with migration, which in turn increases the likelihood of crime and disorder [19]. Factors that entice migration include high wages, labor demand, economic possibilities, and political freedom [20]. It is often assumed that economic migration occurs when individuals leave less developed regions for more developed ones, typically in search of better salaries and more employment opportunities [21]. Motivated by the desire to better their lives and send money back home,

economic migrants migrate willingly [22]. As things are, economic output is low and poverty is rampant in most developing nations and regions, where the majority of refugees call home. Different fields examine migration in relation to societal developments other than displacement since it is a dynamic process [23]. Economic, demographic, and social variables interact to establish the value, skill level, and age structure of migrants from their home country to their host nation, which in turn describes the complexity of migration processes [12]. Regarding the phenomena of migration, It is quite typical for individuals to leave less competitive rural regions for more competitive metropolitan areas in search of better prospects [22].

It wasn't until the fall of the USSR in 1990 that the migratory issue really stuck out. Furthermore, individuals have been compelled to seek improved living circumstances due to factors such as unemployment, inadequate resources, widening regional disparities, and rising instability. Many have sought refuge in the North, where they may enjoy relative peace and prosperity. Depending on the person and the situation, any country might be impacted by the challenges that come with international migration. An essential part of a nation's healthy growth is preventing or minimizing migration, both inside and beyond the country [24]. Immigrants are drawn to developed areas because of their high levels of capital, employment, education, culture, and urbanization [25].

Not only can migration patterns alter people's living conditions, but they also have far-reaching effects on society, culture, the economy, and politics [27]. Many nations are impacted by the migration issue, which has many aspects [28]. Without stable employment, regular income, and access to emergency humanitarian aid, many migrants now confront insurmountable obstacles, including poor health and social services. Two types of migration may take place: movement inside a country and migration between countries. The term "international migration" refers to a movement that has an impact on more than one country [20]. As a result of the modernization process, developing economies have created points of attraction, which stimulate immigration [29]. The political and security agenda is shaped by the social and economic impacts of immigrants in the nations they settle in [30]. Some examples of such events include migration, conflict, political unrest, illness, the birth rate, and societal upheaval. The growth of commerce and industry in the migratory area is a major factor in the persistence of one-way migration [31]. Theoretically, economic considerations are at the heart of voluntary migration [32]. Any migrant movement with an element of compulsion, such as threats to livelihoods, is considered involuntary or forced migration [1]. This includes migrations that originate from natural or human-caused sources. For instance, the coronavirus type 19 (COVID-19) is a pandemic that has moved from country to country, impacted every industry, and brought up the topic of migration. International movement and mobility have been severely disrupted by this epidemic, which has caused numerous challenges, particularly for immigrants. while a result of the COVID-19 pandemic, many individuals were left utterly defenseless for months while they went hungry [7]. There were about 272 million as estimated. In 2019, there were around 3.5 percent of the world's population that migrated internationally [33].

IV. MACHINE LEARNING (ML)

ML is an important component in the field of data science. ML can be defined as a branch of computer science that incrementally increases the accuracy of data by using algorithms that mimic the way humans learn in the field of AI. ML Algorithms are algorithms that accurately predict outcomes without programming any software. The goal is basically to take the data used as input in many algorithms and draw conclusions from the input data, analyze it with new output data, and produce results. This method focuses on how the data is used and how the program will proceed according to the flowchart. The algorithms used in ML are included in the training to make classifications or predictions, and part of the data is allocated for training, and part for testing. Accuracy values are calculated by comparing the predictions with the test data. The ML algorithms used in this study are explained below.

A. Logistic Regression (LR)

Logistic regression (LR) is a statistical method used to analyze a data set containing one or more independent variables that determine an outcome. The logistic regression model is the most commonly used regression model for analyzing data [35]. In LR, the outcome is measured with a binary variable. That is, LR is the appropriate regression analysis when the dependent variable is binary. The purpose of using the LR analysis is the same as other model-building techniques used in statistics. In LR, it is aimed to find the optimal model to describe the relationship between the bidirectional characteristic and a set of related independent variables. Mathematically, LR estimates the multiple linear regression function defined in Equation 1:

Approximately two-thirds of international migrants (about 176 million) lived in high-income countries in 2019 [33]. More

The second dataset named "Indictors.csv" was created using data obtained from "International Immigrant Quantity". Data on the number of immigrants between 1960 and 2010 was used in the creation of this dataset. This dataset was used to calculate the success rate in experiments related to our second application, which used the Xgboost and RF ML algorithms to estimate migration quantity. Regarding the dataset used in this study, the 1960-2010 data for Afghanistan are shown in Table 3 as an example.

In the study, data pre-processing steps were also applied to the datasets. Data pre-processing involves preparing the data for analysis by using methods of data cleaning, data merging, data transformation, and data reduction [36]. In these processes, missing data are added and deleted line by line. In the pre-processing of the data in our study, the columns "region" and "income group" with the value "nan" were deleted row by row in the datasets. One of the most successful methods to complete missing values in the dataset is to average missing and non-missing values [37]. In this context, the missing values in our dataset were completed by taking the average of the non-missing values. As an example of this situation, column-based row numbers of the missing data are shown in Figure 1.

B. Programming Language

This study's experiments made use of libraries and the Python programming language. Among them is the "Pandas" library. Data is collected and made accessible for study using this library. In addition, the "Numpy" library was used for this research. For accurate and fast scientific computations, you may rely on this library, which is also a mathematical one. By including operators and functions that efficiently operate with fields and multidimensional arrays, "Numpy" eliminates the slowness issue. Our apps relied on this library for common mathematical and list-building tasks. With its numerical extension "Numpy," the cross-platform "Matplotlib" toolkit may be used to include visuals like data visualization and charts into the project. The research made use of the "Sklearn" library, the "Pyecharts" package, and the "Bubbly package ". To scale our dataset, we used the "StandardScaler" function of the "Sklearn" package. A popular open-source ML library is "Scikit-Learn (Sklearn)".

The research used Python as its programming language. This programming language was selected for the research due to its user-friendliness, adaptability, and ease of learning. It also provides a command to create code in the program using ML techniques. Anaconda, Eric, Eclipse, and Pydev are a few of the integrated development environments (IDEs) used to create Python programs.

C. Outcomes

Estimating immigrant income brackets was the primary use of the research. Algorithms such as SVM, NB, LR, and KNN were used in this application. An examination of the efficacy and precision of four distinct ML algorithms was carried out in the research. Here, we want to see how well various ML models perform according to our set of standards. Dataset characteristics such as "Migration," "Industry," "Female Mortality," "Male Mortality," "0-14 Age Range," "15-64 Age Range," "Agriculture," "Population," "Deaths Under 5", "Service," and "Territory" were used in the tests. The success rates were updated after each trial in which the number of characteristics was varied. Table 4 displays the experimental outcomes.

In the experiments, a success rate of 86.04% was obtained for LR, 83.72% for SVM, 83.72% for KNN, and 69.76% for NB. It can be seen that the highest success in this application was achieved with the LR algorithm. When examining the success rates of the experiments conducted within the scope of this application, it was found that the success rates ranged from 34.88% to 86.06%. Figure 2 shows the success rates of the experiments LR, SVM, KNN, and NB. For the first implementation in this article, LR accuracy is higher than the other three algorithms.

For the second application conducted to estimate the number of immigrants, the RF and Xgboost algorithms were used and 10 different experiments were carried out. In each experiment, the number of attributes was changed and the success rates were recalculated. Figure 3 shows the results of the experiments performed with the algorithm RF. Figure 4 shows the results of the experiments performed with the XGBoost ML algorithm.

In the second part of the investigation, researchers used XGBoost and found a success rate of 98.37%, while RF attained a success rate of 96.42%. This demonstrates that the XGBoost model is capable of providing a ranking of features in terms of importance. When it comes to tackling sequence prediction issues, the XGBoost's power is essentially the major reason behind this high success prediction rate.

This study's findings show that ML models can accurately forecast human migration. These findings demonstrate the promise of ML algorithms for human migration prediction, independent of the algorithms' performances. There is a great deal of modeling leeway with ML models. Furthermore, ML models may be tailored to address specific issues related to human migration. Countries will greatly benefit from using ML systems for human migration forecast. Decisions pertaining to social issues, the economy, and the environment will be more consistent, and national requirements may be better planned. It may be required, for instance, to forecast fifty years into the future when developing migration estimates of nations. In this case, every year in between must have a high success rate for estimating all variables other than weather events. You may utilize the data acquired by estimating human migration using ML once you've estimated input variables like temperature and drinking water quality for each year.

V. CONCLUSION

This paper presents the results of a variety of ML algorithms that were used to forecast various income brackets and the total number of immigrants. The study's foundation is the application and assessment of several ML algorithms. The study's first application made use of SVM, NB, LR, and KNN algorithms, while the second application made use of RF and XGBoost techniques. This setting was the setting for twenty-one separate studies. The research utilized data from the World Bank 2010 to build two datasets, which were used for the first time. In the first experiment, LR achieved an 86.04% success rate, whereas in the second, XGBoost achieved a 98.37% success rate. The study's trials show that the LR and XGBoost algorithms performed the best in the applications. Future human migration patterns may be better predicted with the help of ML algorithms. This research is anticipated to add to the existing body of knowledge by demonstrating the applicability of AI approaches and methodologies to the study of migration, a pressing issue in the realm of international affairs. In the future, we want to use AI to expand this work and look at how migration is related to climate change.

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