Artificial Intelligence Systems applied to tourism: A Survey

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ABSTRACT
Artificial Intelligence (AI) has been improving the performance of systems for a diverse set of tasks and introduced a more interactive generation of personal agents. Despite the current trend of applying AI for a great amount of areas, we have not seen the same quantity of work being developed for the tourism sector. This paper reports on the main applications of AI systems developed for tourism and the current state of the art for this sector. The paper also provides an up-to-date survey of this field regarding several key works and systems that are applied to tourism, like Personal Agents, for providing a more interactive experience. We also carried out an in-depth research on systems for predicting traffic human flow, more accurate recommendation systems and even how geospatial is trying to display tourism data in a more informative way and prevent problems before they arise.

1 INTRODUCTION
Artificial Intelligence (AI) is the term given to computational systems able to solve tasks without the necessity of human intervention. The application of AI for solving complex problems and finding new solutions has translated in the rise of systems capable of helping humans improving their performance on areas like Marketing [16] and Medicine [21] among others.

The majority of AI systems needs a significant amount of data in order to recognise patterns and produce predictions or classifications on new data. Due to the computational limitations, their full potential can only be explored recently with improved stored capability and processing power.

One sector that hasn’t seen many improvements in terms of AI related content is tourism. Being responsible for 10% of global GDP with a total of 8.9 trillion dollars and 330 million jobs related in 2019, tourism can be a sector to improve with AI systems.

But what is tourism and how can we develop systems capable of solving problems that arise in this complex area? In [19] tourism is defined as a phenomenon that existed throughout the ages but only achieved the form that we know today in the twentieth century. The official definition of tourism is “travelling for business or pleasure; the business of providing tours and services,” and has only achieved the dimensions that we know today due to the easiness of travelling and accommodation.

In 2019, the number of tourists worldwide reached the peak with 1.46 billion persons. Being more popular among developed nations, this is a significant amount of potential clients that companies haven’t explored their full potential yet. Currently the great area that is being explored in this sector is accommodation, with companies developing accessible booking for hotels and private properties. This prompted an increasingly amount of companies to develop platforms for property owners to promote their own spaces and recommend the most suitable accommodation, based on location or preference for tourists planning their trip.

Considering the massive potential of this industry, we analysed the current state of the art works and proposed implementations of computational systems and resume their findings and conclusions. By the definition of tourism and lack of interest besides services for finding and hosting accommodations, we can clearly see some key works that use AI systems, for improving the sector. The majority of these works develop or propose smart tours, in which systems provide a list of places more suitable for a certain type of user, intelligent assistants like Alexa, Siri or Cortana, for guidance, automatic translators for simplified communication and so on. Customer and destination traffic analysis has also been attempted to, not only help companies and decision-makers on finding new trends in tourism, but also segment clients for more suitable locations for a better experience and engagement. Finally, another type of system that was researched were geospatial systems for identifying trending touristic zones, offer city planning locations to implement new services and analyse the impact that tourism has on certain zones, like protected areas.

Considering these types of systems, that can improve and be applied, we have defined four specific groups of similar works. In Chapter 2 we are going to explain what type of works were studied for recommendation systems with tourism destinations in mind and how they have improved, compared with traditional methods. In Chapter 3, we explore an approach to the state-of-the-art pieces on personal agents for touristic services. An in-depth study of works related to customer and destination segmentation systems is going to be a subject in Chapter 4. In Chapter 5, we are going to analyze works related to geospatial analysis systems and how they are being applied to tourism. At last, in Chapter 6 we resume our findings and determine how these works have improved tourism services worldwide.

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1 Data retrieved from https://wttc.org/Research/Economic-Impact
2 Data retrieved from https://www.statista.com/statistics/209334/total-number-of-international-tourist-arrivals/
2 RECOMMENDATION SYSTEMS

Recommendation Systems are a crucial part in online retailers, e-commerce and content providers, because they retain the attention of users for the most suitable items at a given time. A recommendation system is part of a specific area of AI named Natural Language Processing (NLP). A recommendation system is a filtering model that seeks to predict the rating or preference a user would give to an item, being mainly divided in three categories. The first are systems based on collaborative filtering [17] which consists on recommending items that users with similar historic patterns to ours have acquired or showed interest in. Despite being a very intuitive approach, several problems arise from using this type of system. Most setbacks are on how we measure the similarity between users and how to initialise the system in the early phases of implementation, since we lack data. Despite this, several interesting and promising solutions have appeared.

The other type of recommendation systems are those using Content based filtering [23], which labels items with a set of tags and recommends new occurrences based on similar tags. A key issue with systems using content-based filtering is the inability of the system to learn user preferences from their actions. The third and more modern category are hybrid recommendation systems [4] which use a combination of both techniques to improve performance and output the most suitable item to the user. Such hybrid systems are used in [13, 20, 28] and are even patented [24] due to their importance in e-commerce.

For tourism, these types of systems can be developed for recommending destinations or location-based content like cultural shows, monuments or tours more suitable for the user. The work of [2] proposes a hybrid semantic-based recommendation system. This approach can be used to effectively offer items specific to the user’s needs, with their preferences in mind. The developed work that integrates semantic similarity of items with the traditional item-based collaborative filtering approach, enhances the personalization capabilities of existing recommendation approaches. The performance of this new recommendation approach was validated using a real touristic dataset from the Australian tourism domain and has been compared with the traditional item-based collaborative filtering, as a baseline approach for comparison. The experimental evaluation results demonstrate that this approach outperforms three competing approaches in terms of recommendation accuracy and capability to deal with the sparsity and new-item problems. Furthermore, it has been shown that this recommendation approach is feasible and practical for use in real world e-government recommendation systems.

The authors extend the notion of travel recommender systems utilizing collaborative filtering techniques, while also taking more information. The authors refer to this as contextual information such as the current user’s location, time, weather conditions and places already visited by. They use this information for deriving improved recommendations in pervasive environments. The authors also propose the use of a wireless sensor network that could be installed around tourist sites for enabling precise user site. This network should also provide mobile users a convenient and inexpensive way for uploading and accessing tourist information and ratings about points of interest (POI) via their mobile devices. Another aspect they introduce is the concept of context-aware rating, where a user rating is uploaded through wireless infrastructures and are weighted higher to differentiate users that rate POIs using the mobile tourist guide application while onsite, and others using the Internet away from the POI. The usability and effectiveness of this prototype has been validated through extensive user evaluation tests, which captured some real deployment issues and recorded both qualitative and quantitative evaluation parameters.

One work by [2] noticed the lack of tools for tourists in planning their stay at a new location. They also noticed how personalization is becoming one of the main requisites of the tourism sector. Their work focused on developing a personalized sightseeing tour recommendation, based on user’s tourism profile and recommendation techniques. Through the implementation of a Personalized Sightseeing Tours Recommendation System on city councils, tourism sites and tourism kiosk style information access points, or even through tourists mobile devices such as PDA’s, tourism industry, private and governmental, namely regional tourism can be further improved, according to the authors.

In [27] similar approach was also studied but for tour packages from travel collections, since the authors found there was a lack of work on. Their work uses the content-based recommendation method to provide tour package recommendations based on past travel data. To achieve this, the authors developed a hybrid method of mobile-based recommendation system using a combination of the methods of Naive Bayes, Bayes Theorem, and Dempster Shafer. Naive Bayes is used to calculate probabilities of features such as age and frequency of visits. The Bayes Theorem is used to calculate probabilities such as country, gender, and destination. To determine the mass value of a combination of evidence, they use the Dempster Shafer method. Based on the accuracy tests performed, the total accuracy of the tour package by the mobile-based recommendation was 95%, while the error rate of the system in providing tour packages was 5%.

Another approach for developing recommendation systems but without the traditional methods was proposed by [6]. In this piece, the authors aim to build a system to suggest touristic destinations based on a visual matching with minimal user input. Their objective is for a user to send to the system either a photo of the desired scenery or a keyword describing the place of interest, and the system will look into its database for places that share the visual characteristics. To that end, they first cluster a large-scale geo-tagged web photo collection into groups by location and then find the representative images for each group. Touristic destination recommendations are produced by comparing the query against the representative tags.

The main aim of the research of [11] is to improve the capability of software used in touristic agencies, by developing a system supporting real time communication, capable of improving the filtering method. The proposed application was tested based on a case study considering two scenarios. One with disturbance introduced and the second without disturbance. To prove the system’s degree of effectiveness, two indicators were defined and the results indicated that the proposed web application improved the rate of recommendation compared with other platforms. This was achieved.
with real-time data communication on one scenario, which improved the customization of the system. Furthermore, the proposed system performed better in terms of runtime because the web application took immediate action to reschedule items whenever the authors caused strong disturbances. However, this study has some limitations, according to the authors. The first, being that the case study was not tested for real customers. The second drawback is the fact that the communication between the proposed system was not tested via real hotel sector conditions. Thus, the authors stated that a more realistic condition will be tested as future work.

In [3] the authors identified that current recommendation systems rarely aim at recommending tangible itineraries for tourists within a specific POI due to the lack of onsite travel behavioural data and related route mining algorithms. To this end, a novel travel route recommendation system was proposed, which collected tourist onsite travel behaviour data automatically regarding a specific POI, based on smartphone and Internet of Things (IoT) technology. The proposed system pre-processes the behaviour data in order to transform raw behaviour sequences into Tourist Behaviour pattern sequences. Subsequently, the system discovers frequent travel routes from the generated pattern sequences by using an original route mining algorithm, named Tourist-Behaviour PrefixSpan. Finally, a route-recommending method is designed to search and rank tangible travel routes according to the querying tourist’s profile and constraints, like physical limitations. The experimental results demonstrate that the proposed system is efficient and effective in recommending POI-oriented tangible travel routes considering tourists’ route constraints and personal profile, while ensuring that the suggested routes have considerable route values.

3 PERSONAL AGENTS

Personal agents are systems aimed to mimic human interaction for returning an output for a given input. Despite being very common current phones having some type of personal agents, their application for tourism is almost non-existing. Agents like Siri, Alexa or Cortana can provide answers for a wide range of questions of different subjects, but aren’t able to provide a quick and interactive information in tours or holiday guidance. Like recommendation systems, personal agents are a topic of NLP, where the process consists on transforming the user input (speech, text or interface), interpret their purpose and then proceed to give a correct or similar output. Due to the complexity of the task and the multitude of subjects to retrieve information from, it is more suitable and common to create agents for a specific subject, in this case for touristic opportunities. These opportunities range from intractable tour agents for providing insight of a given landmark or object to destination finder in a Point of Interest or on our mobile devices.

In [9] one of such agents was developed due to the lack of knowledge of tourists and to promote Bulgarian culture outside of its home country. Their work details the creation of an intelligent touristic guide that considers various factors, such as the tourist’s preferences, location, time available, and the presence and location of cultural and historical objects in the area. With this information, the agent proposes a virtual or real tour of cultural and historical routes. The agents are also being implemented as an Internet of Thing (IoT) application in order to improve the immersion of the proposed tours.

Similar agents started to being developed but for providing a more interactive tour for museums around the world. One of such agents is described in [7] where a context-aware museum tour guide adjusts its recommendations to the interests and contexts of individual visitors. This tour guide also enables the users to selectively share their experience with others. The guide is built around a Semantic Web framework that is able to minimize the development and maintenance costs associated with the introduction of new exhibits, new visitor-oriented services and new sources of contextual information. The guide was still in prototype stage at the paper creation time and was available at the National Museum of Natural Science, one of Taiwan’s largest museums.

[5] presents a multiagent planning system to solve web problems in the wide network, whose main goal is to search for useful solutions in the electronic tourism domain to system users. The system uses different types of intelligent autonomous agents whose main characteristics are cooperation, negotiation, learning, planning and knowledge sharing. The information used by these intelligent agents is heterogeneous and geographically distributed since the main information source of the system is Internet. Other information sources are agent knowledge bases in the distributed system. The process to obtain, filter, and store the information is performed automatically by the agents and the information is translated into a homogeneous format for high-level reasoning to obtain different partial solutions. Partial solutions are reconstructed into a general solution (or solutions) to be presented to the user. The system will show a set of solutions to the users that can be evaluated by them.

In the recent years, the developed tour guides started to evolve to include more immersive options so Augmented, Virtual (AV) and Mixed Reality (MR) tours started to gain popularity. One system that combined personal agents with these types of tours was the work of [10] which describes the design and development of a novel museum guidance system, based on the immersion and presence theory. This approach examines the influence of interactivity, spatial mobility, and perceptual awareness of visitors within Mixed Reality environments. The developmental framework of a prototype Mixed Reality tour guide program named MuseumEye incorporates the sociological needs, behavioural patterns, and accessibility of the user. The process of data gathering for the tour creation examines the functionality of the MuseumEye application in conjunction with pre-existing pharaonic exhibits, in a museum environment. Results of this research study indicate a high rate of positive responses to the mixed reality tour guide system and the functionality of augmented reality, in a museum environment. This outcome reinforces the suitability of the touring system to increase visitor experience in museums, galleries and cultural heritage sites.

4 CUSTOMER AND DESTINATION PREDICATIVE SYSTEMS

One major capability of modern computational systems is being able to predict new values based on previous experiences. For the tourism sector several authors saw this as opportunity and started
to plan and develop systems capable of predicting the flow of tourists, in a specific time-frame. Not only they intended to predict human flow, but also determine how certain events can increase or decrease the amount of clients. Early systems were those developed by [26]. This study presents two models that can be used to predict tourism demand. These two models are based on neural networks systems, whose function is similar to the human brain, and were applied to tourist demand forecasting, in 2000, and empirically tested using raw data from Hong Kong. One point this work concludes on is that using empirical evidence and grey theory combined with fuzzy time series will cause the models to not need a large sample and long past time series, for predicting tourism demand. These AI models were estimated for tourist arrivals to Taiwan from Hong Kong, United States and Germany, during the period of 1989–2000. One model achieved an accurate forecast when the sample data indicated a stable increase trend. Nevertheless, the Markov modification model can be more efficiently than the previous model, in which the sample data shows significant fluctuations.

Following the previous work, [29] examined the forecast accuracy of fuzzy time series with grey theory in predicting annual U.S. tourist arrivals. The performance of two artificial intelligence models is compared to that of two simple methods, the double moving average and the double exponential smoothing. The rigorous testing approach includes a large sample stratified to adequately represent four generic trend patterns: a rolling short-term forecast, a large holdout sample, models fitting with both equal number of years and optimal number of years, and tests of statistical significance using Wilcoxon signed-ranks non parametric test. This study’s findings indicate, in contrast to recent findings, that the complicated models are not likely to generate a more accurate forecast than the simple traditional models. Given the notable cost associated with these AI forecasting methods, the authors find no significant accuracy advantage suggesting that tourism forecasters should not rush to adopt these two methods without careful consideration.

More recently works using the full capability of computational power and data mining techniques to develop predicative models with higher accuracy started to be more common and groundbreaking. In [12], an auto-regressive approach to predict tourism demand using past arrivals is developed. These models aim to predict arrivals based on big data information as input features like the destination price level or the web search traffic per sending country, respectively. As prediction methods, the study uses the statistical approach of the linear regression and the data mining technique k-nearest neighbor (k-NN). Both approaches are executed and evaluated for the leading swedish mountain destination and are on the base of arrival data and big data sources, for the time period of 2005–2012. Study results show that big data information sources can significantly increase the prediction performance of tourist arrivals, compared to using past arrivals alone (i.e. autoregressive approach) and data mining techniques (i.e. k-NN) to outperform statistical approaches, like linear regression.

Similar work was developed by [15] which proposed a new forecasting framework with search trends data, which was applied for prediction of Beijing tourist volumes. At first, the authors introduce a generalized dynamic factor model (GDFM) that uses the common components of search trends data to construct a comprehensive index. In a second phase, they compare this new index with a time series model and the Principal Component Analysis (PCA) based index model. Then they evaluate the performances of the econometric models with different indices using static and dynamic tests. The empirical study indicates that the framework has a more favorable performance than other econometric models. First, a significant co-integration relationship exists between the index and Beijing tourist volumes. Second, Granger causality tests suggest that search trends data lead the actual tourist volumes. Thirdly, they demonstrate that the econometric model with the new index has the best forecasting accuracy in the one-week and four-week forecasts. They also conduct the rolling window forecasts for the robustness check. The empirical results validated the framework, which offers a suitable solution for better manipulating large-scale search trends data. This study indicates that the search trends data index provides more accurate forecasts of tourist volumes than other indices, in which the authors reveal that we should monitor this aggregated index to better capture the dynamics of tourist volumes. In addition, this study demonstrates that this new index has the best forecasting performance in short-term forecasts.

5 GEOSPATIAL SYSTEMS

Geospatial analysis is the subject of gathering and interpreting data from aerial photographs. Due to the necessity of a high-altitude plane or satellite with a high-definition resolution camera, the gathering of such images was complicated to obtain and to interpret. With the improvement of quality on these images and the growth of sources to provide them, systems using geospatial data for civil-  

ian applications started to emerge. One area that geospatial systems started to be developed for was city planning by analyzing how the growth of the cities has influenced several aspects, and to find new prominent areas for certain developments. Nonetheless, some works tried to use these types of images not only to find potential touristic spots, but also to assess the damage that tourism has caused in natural environments.

The work of [22] used modern spatial computing technology for the development of a special tourism policy and planning, in the context of a bounded resource base. It is briefly referred that the provincial tourism development policy and the tourism marketing framework use them to express tourist preferences and to determine suitability indicators. Not only that, but also the attraction features for a spatial tourism resource base, attention to the conceptual foundations of attraction and the mapping of tourism potential variables. The work applied this methodology to a combination of tourism products in the Western Cape Province of South Africa, in an approach that involved applying the spatial multiple criteria evaluation. This was achieved through the weighted linear combination of spatial factor layers as images, in a geographical information system. It has performed an analysis of the gap between tourism potential and tourism resource provision at a spatial resolution of individual town spheres of influence, as represented by Thiessen polygons. The outcome is a map format that demonstrates the applicability of these techniques to the Western Cape. The fine-scale spatial result was analyzed for its strategic planning implications. The author results are useful for entrepreneurial and
regulatory planning and can be replicated in different spatial locations, if the appropriate database is constructed.

[18] examined the U.S national geospatial supply and demand for overnight accommodations on federal lands prior to the 2008 recession. This was accomplished using 7.5 million reservations made for federal recreational facilities (campsites, cabins and overnight group sites), between 1999 and 2007. Visitor origin frequency and median travel distance associated with overnight accommodation reservations are summarized for each facility and for each customer through their zip code. Utilizing overnight camping and lodging reservation data for federally managed sites can help facilitate data-driven planning and marketing efforts by national parks and their gateway community stakeholders. According to the authors, the understanding of geospatial demand for specific destinations can improve management and marketing decisions, affecting natural preservation, visitor enjoyment, and community planning. The data analytics and visualization approaches presented in this paper used a combination of commercial Geographical Information System (GIS) named “ArcGIS” 10 and a free web-mapping application “MapMyClients”, that was designed specifically for tourism researchers and professionals. The latter can be used to identify demographic information that may be useful to managers and decision-makers as they plan marketing campaigns. Using these tools, the authors can define market demands and demographically profile their customers, allowing for smarter, data-driven decision making. While this study has focused on the gateway communities associated with national park attractions, the authors also stated that this methodology can be applied easily to other destinations, where visitor origin information is being collected by individual businesses, chambers of commerce, or tourism bureaus.

In [25], a geospatial approach has been applied to assess the impact of tourism on land use/land cover and natural slope of a specific touristic area. For this, satellite images of 1989, 2000, 2005 and 2012 were used to detect alterations and ASTER digital elevation model was used for slope analysis. Impact of tourism in the study area was assessed through change in built-up and its sprawl on various slope classes over the years. Built-up increased from 4.7 to 15.7% during 1989–2012 indicating fast growing development in the area. At the same time, an exponential increase in the number of tourists, from 1980 to 2011, confirms excessive pressure of tourism in the study area. Additionally, the number of hotels has increased over the years. Built-up is observed in a gentle slope to very steep slope and is increasing year by year. The study area is prone to landslides and an increment in built-up especially in extreme, steep and very steep slope, becoming a matter of grave concern according to the authors. This study suggests that immediate attention of city developers and planners is needed to achieve the long-term viability of tourism industry through sustainable developments and to avoid future catastrophes.

Similar work is done in [14], but with a focus on forest wildfires. The authors developed a model to articulate forest fire risk of tourist spots, so that the authorities can minimize the danger caused. These models were generated using fire risk models with Multi Criteria Decision Analysis, Analytic Hierarchical Process, Fuzzy techniques and a tourism model. The gradient of tourist potential sites was created in a Geographical Information System (GIS) environment with binary weighted overlay methods. The potential touristic sites were generated and overlaid to produce a final tourism suitability potential map. Fire risk indicators were created in GIS using statistical modelling knowledge based weight age, AHP and Fuzzy logic. For each fire risk map, 5 classes were assigned and out of these, high and very high-risk zones were overlaid to generate a final fire risk map using raster calculator in GIS. Final hazard map was prepared using overlay operations of forest fire risk model and suitable tourist site with GIS. In [8], a conceptual framework illustrating the complex relationships and trade-offs among threats from coastal tourism and from other coastal ecosystem services is presented. In this work it is discussed the negative feedbacks of tourism development and provided examples of geospatial analysis on cumulative threats generated by other human activities and affecting tourism itself. The proposed conceptual framework and the threat analysis aim at highlighting the negative feedback effects of human-driven threats on the development of Mediterranean coastal tourism, through an ecosystem service perspective. The tools developed provide valuable insight for supporting decision-makers and planners in achieving integrated coastal management, with a focus on sustainable tourism.

6 FINAL NOTES

This paper consisted of a small survey of works where computational systems are used to find or improve current aspects in the tourism sector. Since tourism is a wide area, we opted for defining four distinct areas that we think are relevant for current market trends and will gain popularity in the near future. In the area of recommendation systems, we find that the majority of works are done to improve or developed systems for recommending local points of interest and shows. There were also a few works where the target for these systems were destinations and suitable packs for customers.

For personal agents for tourism we noted that personalized mobile based agents were suited and applied to tours and combined with recommendation systems for providing the most optimal tour for the user. We detected a great deal of works trying to combine these type of agents with Internet of Things technology to be more efficient and more immersive. We also identified a new trend of combining these agents with Augmented Reality so that tours are more easily explained and more immersive.

There were several ambitious works trying to predict the flow of tourism in certain areas. Due to the complexity of the problem, the analyzed works didn’t achieve groundbreaking results but showed some promise in identifying cause factors for destination popularity and Point of Interest congestion.

The final area we focused our work on was geospatial systems with tourism emphasis. We identified works using geospatial images to help decision-makers segment tourists and find new areas to promote their location. We also noticed several works using geospatial systems to analyze tourism impact in natural and urban zones in order to report and advise local governments and decision-makers. Some works also assess touristic areas for potential hazards and minimize problems before they arise.

With these four areas, we cover a wide range of systems developed for the tourism industry that we believe will continue to be
improved and ultimately solve modern problems, further innovating this highly profitable sector.

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