

Integrating social sciences research with artificial intelligence (AI): a case study from the Great Barrier Reef

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Abstract

Artificial intelligence (AI) presents unprecedented opportunities to develop automated systems for tourism planning, marketing and management. This paper argues that AI systems are most effective if they are designed and developed based on theoretical and empirical insights gained from social science research. This paper introduces an example of how social sciences and AI research are complementary in developing an aesthetic monitoring system for the Great Barrier Reef, Australia. Benefits and challenges of combining social sciences and AI are discussed, focusing on the need to applying a human-centred approach in tourism technology development. The paper also suggests directions for future cross-disciplinary research to advance our knowledge base and management tools in tourism.

Keywords

Artificial intelligence, social sciences, tourism planning, tourism management, aesthetics

Introduction

Artificial intelligence (AI) is developing rapidly in many areas, including tourism. The concept of AI was first introduced at the Dartmouth Conference of 1956 and is defined as "the science and engineering of making intelligent machines, especially intelligent commuter programs" (Skilton & Hovsepian, 2018, p. 78). In tourism, AI systems have been designed and used for generating automated recommendations (Fesenmaier, Wöber, & Werthner, 2006; Zsarnoczky, 2017); offering services automation in hotels and restaurants; supporting marketing decision-making (Stalidis, Karapistolis, & Vafeiadis, 2015); managing customers' online reviews (Ku, Chang, Wang, Chen, & Hsiao, 2019; Schuckert, Liu, & Law, 2015) and monitoring customer satisfaction (Moutinho, Caber, Silva, & Albayrak, 2015). These kinds of AI applications have fundamental impacts on the tourism and hospitality industry, especially when combined with new business models (e.g. sharing economy) and smart systems more broadly (e.g. internet of things or internet of people). Some argue that AI has revolutionised the way tourism and hospitality stakeholders function (Gretzel, Sigala, Xiang, & Koo, 2015; Zsarnoczky, 2017), opening the door for building smart tourism destination (Tsaih & Hsu, 2018).

While the potential of AI for process automation, efficiency gains and value creation is well established (Werthner, 2003), researchers also point out the challenge in making the AI systems more "human" (McCarthy, 2007). It seems that harnessing the vast and valuable research in social sciences including philosophy, psychology, cognitive science, tourist behaviour should be vital in developing more

explanatory AI systems to reduce bias in algorithm design (Hassabis, Kumaran, Summerfield, & Botvinick, 2017; Miller, 2018). Recognising the interdisciplinary nature of AI, it has been noted that "Everything from humanities and social science to art and design has a place in AI. AI is not closed off to just maths and computer science the same way that journalism is not closed off to just book reviews" (The Analytics, 2018). Unfortunately, there remains a critical lack of social science perspective in the discourse of tourism and technology studies (Gretzel, 2011).

Against this background, this paper introduces an insightful example of how social sciences research is complementary in designing, interpreting and improving the AI system for monitoring the aesthetic value for the Great Barrier Reef, one of the most well-known tourist attractions in Australia. Based on this case study, the benefits and challenges of combining social sciences research and AI are discussed. Specifically, the paper calls for more social sciences research in designing human-centred AI systems, concluding with recommendations on future directions for advancing the field.

Literature review: Aesthetic research & AI aesthetic measurement systems

The history of aesthetic research is quite long and can be traced back to Plato in his consideration of beauty (Charters, 2006). Aesthetic research began as a branch of Western philosophy investigating the nature of art, the evaluation of beauty and the scope of aesthetic experience. Later, aesthetics become a subject of investigation in many disciplines, including psychology, biology, anthropology, marketing (Dickie, 1997). Aesthetics can be defined as "the study of the feelings, concepts, and judgements arising from our appreciation of the arts or of the wider class of objects considered moving, or beautiful, or sublime" (Blackburn, 2005, p. 8). Therefore, the core of aesthetics is the nature and value of beauty (Armstrong, 2004; Scott, Le, Becken, & Connolly, 2019).

The debate regarding the objective and subjective nature of aesthetic beauty remains inconclusive (Lothian, 1999). Based on the 18th century Kantian idea of disinterestedness and picturesque, the objectivist paradigm assumed that beauty is an objective and intrinsic characteristic of an object and thus not subject to human evaluations (Beardsley, 1975). Aesthetic evaluation is simply the recognition of the target object's intrinsic beauty (Hagman, 2002). The ability to recognise the objective beauty of objects is an important human capacity, leading to a sublime and exalted state (Todd, 2009). The subjectivist paradigm in aesthetic research began in the 20th century. It argues that "beauty is in the eye of the beholder" because human aesthetic evaluations vary across different viewers and cultures (Hekkert & Leder, 2008). Beauty is a product of the mental processes of human beings involving prior knowledge, experiences, values and desire (Datta, Joshi, Li, & Wang, 2006; Le, Scott, Becken, & Connolly, 2019). Overall, researchers seem to conclude that beauty may be quasi-objective (Charters, 2006). Aesthetic evaluations are "certainly not fully objective, but neither are they fully subjective since they are based to some extent on criteria capable of being objectively determined" (Solomon, Pruitt, & Insko, 1984, p. 116).

The objective approach underlies the development of current AI systems in evaluating and quantifying aesthetics. Machine-based approaches to aesthetic monitoring involve the use of Deep learning (i.e. Deep Convolutional Neural Networks (CNN)) for object recognition and assessment of image aesthetics (Becken et al., 2018; Mandal, Connolly, Schlacher, & Stantic, 2018; Seresinhe, Preis, & Moat, 2017). Haas et al., (2015) found that a standardised computational algorithm of 109 visual features (e.g. colour intensity and diversity of the image, relative size, colour, and distribution of discernible objects within the image, and texture) was able to generate the aesthetic values of natural images. These aesthetic values proved accurate predictors of an established biogeochemical assessment of natural sites, reflecting changes in the objective beauty of natural environments (Haas et al., 2015). Using human aesthetic evaluations of outdoor places, neural networks can be trained to automatically identify scenic places and provide a deeper understanding of what environments people find beautiful based on 120

visual features (Seresinhe et al., 2017). AI can also be designed to understand aesthetic meanings embedded in images, and to describe image aesthetic quantitatively and universally (Ma, Jia, Hou, Bu, & Han, 2018).

Overall, the objective approach in AI aesthetic measurement system consists of a critical weakness in the existing literature because the current AI aesthetic measurement systems were all developed based on object recognition without considering the human subjectivity of aesthetic assessment. As tourist aesthetic assessment of a place is not necessarily related to environmental conditions (Vercelloni et al., 2018), AI aesthetic measurement systems based on object recognition may not plausibly reflect human aesthetic assessment. Therefore, a human-centred approach in designing the AI aesthetic monitoring system that incorporates the collective sense of human aesthetic assessment is more beneficial for long-term environmental planning and tourism management. The development of an automatic AI aesthetic monitoring system allows the reef managers to demonstrate key aesthetic values of a nature-based tourism destination which was given protected (or World Heritage) status like the Great Barrier Reef and report tourism benefits from conservation programs (Marshall et al., 2019).

Methods & results

The Great Barrier Reef (GBR) is a well-known tourist attraction in Australia. It is known for its superlative beauty, attracting several million tourists every year (Le, Scott, & Lohmann, 2019). Aesthetics are the most important value of the GBR voted by tourists, residents, indigenous locals and tourism businesses (Marshall et al., 2018). Environmental degradation of the GBR as a result of declines in water quality and coral bleaching events is likely to affect the aesthetic value of the Reef, and this, in turn, has the potential to negatively influence tourists' interest in visiting the site (Coghlan & Prideaux, 2009). Given that tourist visitation and conservation behaviour are both inspired by their aesthetic appreciation of nature-based destinations (Kirillova, Fu, Lehto, & Cai, 2014; Scott et al., 2019; Skibins, Dunstan, & Pahlow, 2017), developing an effective and efficient system for aesthetic monitoring is crucial for environmental planning and tourism management. Automation could assist in reducing costs whilst increasing accuracy. As such, an AI-based aesthetic monitoring system could present a viable option for environmental and tourism managers.

The Government-funded project of developing an aesthetic monitoring system of the Great Barrier Reef presented in this paper was informed by previous research undertaken by the research team on using big data approaches for social media monitoring at the GBR (Becken, Stantic, Chen, Alaei, & Connolly, 2017). One of the core tenets of this project was to apply a human-centred approach to AI development, conducting social science research in identifying aesthetic attributes and quantifying their contribution to the Great Barrier Reef beauty before creating the AI system. The human-centred approach is justified because the automated aesthetic monitoring system serves to predict the common sense of tourist perceived beauty of the GBR and thus needs to be built based on human aesthetic evaluations (Galanter, 2012; Seresinhe et al., 2017).

More specifically, two social science studies were conducted to build the theoretical basis for AI development as well as interpreting AI outcomes (Fig. 1). In the first stage, eye-tracking research was used to identify key features/species that contribute to tourist perceived beauty of the GBR. In the second stage, an online survey collected data to quantify the relative contribution of key aesthetic features to under-water beauty. This survey also collected human aesthetic evaluations of 2500 images (i.e. 'beauty scores'). Results of these two studies generated insights and data that were necessary inputs into building the neural-network-based beauty rating system for the Great Barrier Reef images. These two studies also consist of the theoretical basis for evaluating and interpreting the AI system' outcomes in the last stage.



Fig. 1. Multi-stage research design to develop an automated aesthetic monitoring system for the Great Barrier Reef

Stage 1: Identifying aesthetic attributes using eye-tracking research

Eye-tracking technology was employed as an efficient tool to explore how tourist visual attention is related to their aesthetic evaluations. Eye-tracking measures visual attention processes in terms of eye-fixation counts and duration on particular images and/or areas of interest (AOI) within an image (Scott, Zhang, Le, & Moyle, 2017), which reflect human aesthetic preference for beautiful and pleasant scenes (Calvo & Lang, 2004; Scott et al., 2019). Tourist aesthetic evaluations, in this case, are considered as a personal judgment based on pleasant emotional reactions to a GBR photo, reorienting visual attention toward the image and features/objects that are perceived as beautiful (Nummenmaa, Hyönä, & Calvo, 2006; Simola, Le Fevre, Torniainen, & Baccino, 2015). Eye-tracking research shows a significant relationship between eye-tracking measures (i.e. fixation counts, fixation durations) and tourist aesthetic evaluations of GBR pictures (Scott et al., 2019). Based on tourist visual attention, aesthetic features/objects in the GBR scenes (e.g. fish, coral, turtle) were identified and selected for the next research stage.

Stage 2: Understanding human aesthetic evaluations by a quantitative survey

The follow-up survey was designed based on eye-tracking results, providing data for algorithm development. Preliminary research showed that the presence of an object perceived as beautiful (e.g. a turtle) could significantly improve human aesthetic evaluation of similar GBR scenery (Le, Scott, Becken, et al., 2019). The survey included both quantitative and qualitative components, consisting of three main sections: section 1 for testing the importance of aesthetic attributes (fish, coral, turtle, water quality) in influencing tourist aesthetic assessment; section 2 for getting tourist aesthetic assessment of 2500 GBR images; section 3 including open-ended questions to elaborate further the aesthetic

attributes to the GBR beauty. The outcomes of the survey were used to inform the design of two AI systems for automatically recognising the aesthetic species and assessing the GBR aesthetics (Fig. 1).

Stage 3: Developing the AI system (training and testing)

The AI system aims to predict the aesthetic value of GBR images, using deep learning (i.e. involving a neural network with multiple hidden layers). We propose a novel Deep CNN architecture for image aesthetics assessment consisting of state-of-the-art classification module. The network was then trained with the publicly available large-scale aesthetic dataset (i.e. AVA) and finally fine-tuned (it is a method during the AI learning process to improve the performance) with the data developed by social science research on aesthetic scoring of GBR images (Fig. 2).

The dataset of the Great Barrier Reef images (i.e. the GBR dataset) was established based on 2,500 underwater GBR images, which were downloaded from the Flickr social media platform and rated in the previous survey (i.e. stage two). At least 10 survey participants provided an aesthetic score for each image and the mean score was calculated. Most of the images (i.e. 80%) served as training material to enable the proposed Neural Network model to learn key feature parameters. The remaining 20% of the data were used during the test and validation phases. The validation dataset helps to understand the system performance in terms of accuracy during the training phase, whereas the test set is normally used once the training phase is completed and ready for deployment.

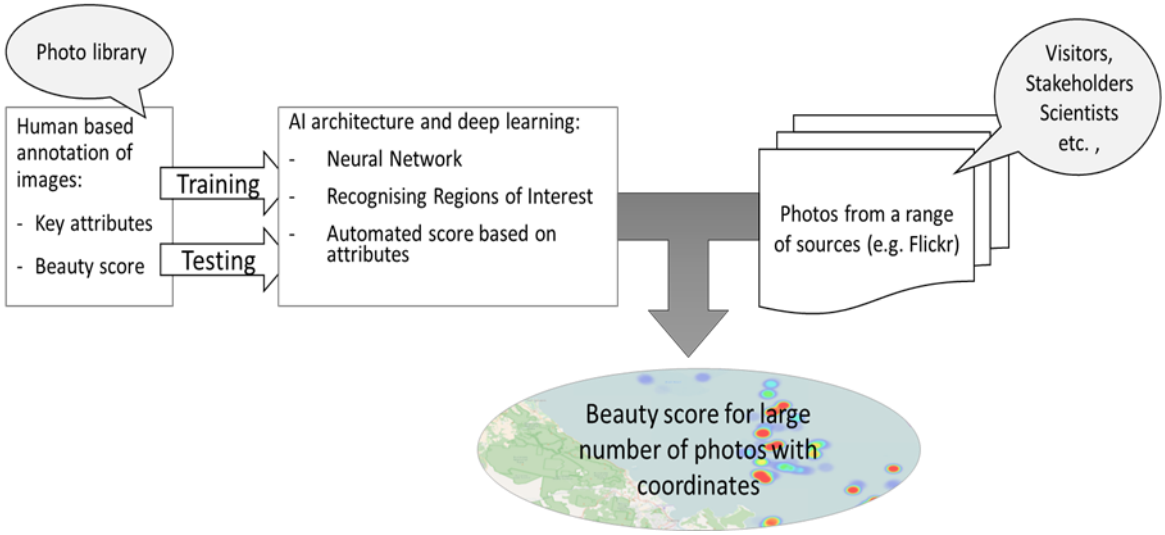


Fig 2. The process of developing an automated system for rating underwater beauty

To better understand the distribution of 'beautiful' and 'ugly' pictures in the dataset, Fig. 3 presents the number of images with scores above or equal/below 5. More than 2,080 images were scored as highly aesthetic (score >5) and only 420 (score <=5) images were scored as having low aesthetics. Fig. 3 also shows how many images of high and low scores were used in each experimental stage.

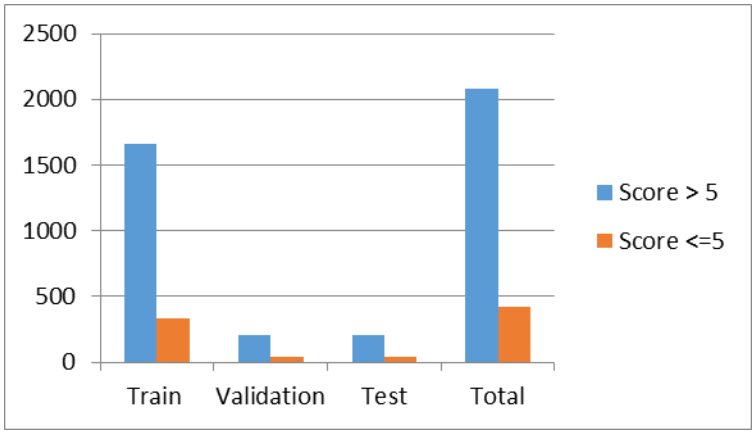


Fig. 3. Score distribution of the GBR dataset, containing a total of 2,500 images.

Stage 4: Interpreting AI outcomes

Outcomes of the aesthetic monitoring system for the Great Barrier Reef were reviewed and interpreted in the last stage. The AI system shows that the pool of GBR images is unbalanced with the majority of beautiful pictures despite recent reef degradation events such as coral bleaching in 2017 (Hughes, Kerry, & Simpson, 2018; Stuart-Smith, Brown, Ceccarelli, & Edgar, 2018). Results of the two previous social sciences studies were used to interpret the AI system outcomes: people appear to pay more attention to aesthetic species and give higher importance to these aesthetic elements when evaluating the beauty of the reef. Hence, the presence of aesthetically pleasing species such as turtle, colourful fish compensates the degrading coral (Le, Scott, & Lohmann, 2019).

The interpretation process suggests practical implication in using the AI aesthetic monitoring system for the Great Barrier Reef. While the AI system should be integrated as an important criterion for environmental management and tourism management decision-making, users of this system should rely on theoretical outcomes of these two social sciences studies for accurately understanding what is happening in the Reef regions; why the aesthetic score is increasing/decreasing over time and how to react to maintain aesthetically pleasing places for tourism development.

Discussion

This paper presents an example of how a combined social sciences and AI research design could be beneficial in developing an automated aesthetic monitoring system for a natural site of both ecological and human significance. Social sciences research plays a crucial role in supporting AI development: informing the design of AI systems as well as interpreting research outcomes. AI systems require a large amount of quality data for conducting the training and test experiments during the development process to be successful. Social science research played a pivotal role in engaging people by conducting online surveys to prepare data, which eventually produced a useful dataset for training and testing our algorithms. The benefits and challenges in integrating social sciences and AI research are discussed, suggesting future directions for advancing the field.

Benefits of integrating social sciences research with AI development

Social sciences research provides important input for developing human-centred AI systems which are more useful than purely data-driven AI in reflecting human aesthetic evaluations. Previous AI studies developed the automated aesthetic assessment systems based on recognising visual features only,

without taking into consideration the subjectivity of human aesthetic evaluations (Haas et al., 2015; Lu, 2016). These AI systems can provide accurate predictions of the environmental conditions. However, tourist aesthetic assessment is not necessarily related to the reef environmental conditions (e.g., reef health) (Vercelloni et al., 2018). Tourist aesthetic assessment is influenced by the "ideal" representation of the Reef (Fenton, Young, & Johnson, 1998), sensory perceptions of the places (Pocock, 2002; Tribot, Deter, & Mouquet, 2018), as well as social meanings (Ma et al., 2018). Therefore, AI systems built on recognising visual features are not able to fully reflect the collective sense of human aesthetic evaluations for environmental changes of the Great Barrier Reef (Galanter, 2012; Seresinhe et al., 2017), which is vital for making decisions related to tourism planning and tourism management. In our research project, a human-centred approach was applied to develop the automated aesthetic monitoring system for the Great Barrier Reef. It is implemented through collecting human aesthetic evaluations of the GBR images to train and test the AI system. The application of a human-centred approach in developing the automated aesthetic monitoring system for the GBR allows researchers to take into consideration human factors and provide more accurate predictions of tourist aesthetic assessment of the GBR sceneries (Seresinhe et al., 2017).

Social science research also consists of the theoretical basis to interpret AI prediction outcomes in a meaningful way. When big data and AI development are exploited from a data-driven approach, these advanced technologies can deliver interesting patterns and findings, but often there is little explanatory power because we do not know 'why' these patterns emerged (Mariani, Baggio, Fuchs, & Höepken, 2018). Results of the two social science studies in our research project show that tourist aesthetic assessment of the GBR images is biased by their preference for colourful fish (Le, Scott, & Lohmann, 2019), which explain why the database of GBR images evaluated by AI system is unbalanced with the majority of beautiful pictures despite recent coral bleaching events. It suggests the possible gap between coral reef health evaluated by biological experts and tourist aesthetic assessment of the GBR sceneries, highlighting the importance of understanding human empathy and compassion in persuading visitors to protect aesthetically appealing sea animals (Marsden, 2018; Weaver & Jin, 2016). Therefore, future AI development projects in tourism should incorporate a component of social aspects, considering the psychology of tourist and applying a human-centred approach (Berka & Plößnig, 2004; Tussyadiah, 2014).

Challenges of integrating social sciences research with AI development

The biggest challenge for a cross-disciplinary research projects is to build a research team with different expertise; amongst others due to different use of 'language' and research protocols. Due to researchers' various backgrounds and knowledge, it may be challenging to have a common understanding of the project objectives and a collaborative way to implement different research components. Interdisciplinary research needs a sound basis for collaboration and ongoing communication within the research team.

Another challenge is to convince stakeholders to invest a considerable amount of financial and human resources for a project incorporating both social sciences and AI development. In the short-term, it may be "cheaper" to fund a (small scale) social science survey, whereas investing in a large interdisciplinary team is more costly at least upfront. However, the 'product' of a social-science-informed AI system should pay off in the long-term, with its great potential to deal with much larger data volumes and achieve better outcomes in terms of cost-effectiveness (Ivanov, Webster, & Berezina, 2017).

Conclusions and Implications

The future of tourism will be focused on human-centric technologies (Buhalis & O'Connor, 2005). Based on reporting the implementation and outcome of our research project, we suggest that a human-centred approach for developing AI systems in tourism will be beneficial to advance the field, in particular, for



evaluating and predicting human evaluations. This area has great potential for future research directions, for example, the fields of neurotourism and artificial intelligence (AI). Neuroscience and AI have a long and intertwined history. A better understanding of biological brains could play a vital role in building intelligent machines. Current advances in tourism AI systems should be inspired by the study of neural computation in humans (Hassabis et al., 2017). Moreover, more projects incorporating tourist psychology research and AI development are useful to improve the effectiveness of intelligent systems in tourism, better design technology for satisfying tourist specific needs and expectations (Gretzel, 2011). Moreover, our research ultimately reduces the aesthetic value to visual elements (albeit derived with a strong human component) and it is important for stakeholders to understand that aesthetic perceptions extend beyond the visual. Further research should determine the extent to which sensory elements contribute to overall perceived beauty.

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