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Assisting Tourism in Underserved Areas with TensorFlow: A Proof-of-Concept Mobile App

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Abstract: Tourism contributes approximately 3% to the GDP in Africa. One of the big attraction to tourists visiting Africa is the wildlife – both the fauna and flora. The larger game reserves and national parks have a wide variety of supporting facililtes such as good access roads, accommodation, food services, and professional game rangers to assist tourists in identifying plants and animals. The smaller less known game reserves, however, often do not have the luxury of these supporting facilities and often lack professional game rangers. These reserves are often avoided by tourists. The surrounding communities, therefore, miss out on the additional economic advantage of having tourists in the area who also need to purchase petrol, buy food, and find accommodation. The paper investigates the use of Google TensorFlow in identifying African mammals. The actual TensorFlow model is trained using traditional desktop workstations and thousands of photographs. Once the model is created, it can be downloaded to an Android device and used in offline mode. This would allow tourists visiting smaller less known game reserves to identify animals and plants in areas where there is no Internet connectivity. The project was a proof-of-concept and the idea can be expanded to include bird watching clubs, fishing clubs, in addition to national parks. The results are very positive. The Android app developed for this research could reguarly identify 35 common African game mammals.

Keywords: tourism, tensorflow, machine learning

1. Introduction

The World Travel and Tourism Council's 2017 annual report (with data from 2016) for Africa indicates that the direct contribution to the GDP in Africa was US$66.4 billion or just over 3% of total GDP. The total contribution (as opposed to direct contribution) was US$165.6 billion or 7.8% of GDP. The industry directly supports over 8 million jobs and the total contribution towards employment was over 20 million jobs. These values are expected to increase in the next ten years. By 2027, the direct contribution to the GDP of Africa is expected to be US$106.8 billion with a total contribution of US$268.2 billion. The industry is expected to directly support over 11.6 million jobs in 2027 with a total contribution to employment being forecast at 28.7 million jobs [1].

These values show the importance of tourism to African economies. One of the big tourist attractions in Africa is the wildlife. Destinations such as the Masai Mara Reserve in Kenya, Serengeti National Park in Tanzania, Chobe National Park in Botswana, Kruger National Park in South Africa, and Etosha National Park in Namibia attract a large number of visitors. The annual number of visitors range, however. For example, Khaudum National Park in Namibia attracts less than 3,000 visitors annually [2]. The Serengeti

National park website reports that the Serengeti park attracts ninety thousand visitors per year [3]. The 2016 South African National Parks annual report indicates that 5.9 million people visited South Africa's national parks during the year under review [4].

Besides the wild animals, popular game reserves also require additional features in order to successfully attract tourists. These features include good access (such as good tar roads or landing strips for aircraft), accomodation (such as tented camps, hotels, guest houses, etc), petrol stations, food services, drinking water.

Many of the larger parks have professional game rangers to assist tourists and make their game drives more pleasurable by identifying the wide variety of animals and plants. Unfortunately, many of the smaller less known parks do not have this luxury and visitors are left on their own to try to identify the flora and fauna. This can be overwhelming to foreign visitors.

This paper describes a proof-of-concept mobile app to assist tourists in such cases. This paper looks at how Google's new TensorFlow can be used to assist tourists at the small less known game reserves. TensorFlow is an interface for expressing machine learning algorithms and also executing those algorithms. TensorFlow is fairly flexible and can be used to express and execute a wide variety of algorithms [5]. This research looked at using TensorFlow to learn to identify African mammals to create a type of "virtual game ranger" for areas where there are no professional game rangers available. Many of the game reserves and national parks do not have cell phone coverage and, therefore, do not have internet connectivity. By using TensorFlow in a mobile app in offline mode, visitors to remote game reserves can still have assistance in identifying fauna and flora using a type of "virtual game ranger". Trained TensorFlow models could be downloaded to mobile devices when the tourist is within internet connectivity. The trained model could then be used in an offline mode to identify animals when there is no internet connectivity. The training of the Tensorfow model means the model is learning the patterns in the training data in order to properly predict the input image.

Although this paper does describe an initial proof-of-concept app and project in using TensorFlow in an offline Android app to identify large African mammals, the important point of this paper is that this technique can be used on all types of wildlife. For example, bird watchers may wish to have a model which has been "trained" to identify indigenous bird species. Fishermen may wish to have a model which has been "trained" to identify fish species in a specific river. A national botanical gardens may wish to have a model which is has been "trained" to identify indigenous plants. Although this proof-of-concept was "trained" for large African mammals, the concept is extendable to a wide variety of wildlife.

It is important to note that this research is not about replacing professional game rangers. It is about assisting tourists in underserved areas where it is not economically viable to have professional game rangers available because of the low volume of tourists. By assisting tourists in such areas, the surrounding areas will have economic benefit by an increase in visitors purchasing petrol, accommodation, food, and other amenities.

2. Literature Review on Image Recognition Algorithms

In order to identify animals from photographs, various image recognition techniques could be used. This section identifies a number of different algorithms.

K-nearest neighbour is a classification algorithm which classifies the input image by determining the most common classification amongst the K number of closest data points in the training set. This process makes use of the features being input to the algorithm and then the distance between the vectors is calculated by a distance metric [6]. This algorithm however does not learn, it does not become smarter, and depends on the distance metric and the number of neighbours used to determine its accuracy.

Images can be classified by a Support Vector Machine (SVM) by creating hyper planes in a multi-dimensional space. SVM's aim is to find the optimal line to separate the classifications. This is done by finding the line which result in the greatest minimum distance to the training data. The features of an image are entered into the SVM which predicts the region into which the input falls. This region then provides the classification of the input [7].

Image classification can be done through Hidden Markov Models (HMMs). Statistical models are constructed for all the possible image classifications [8]. The input image features are entered into each of these models. Each model outputs a probability that the input matches the model. These output probabilities are compared and the highest probability is decided as the classification of the image. A decision tree works well for image classification only if the feature extraction methods used are adequate. The image features are entered into the decision tree, and according to which branches the features take, the image can be classified [9].

Artificial Neural Networks (ANNs) are commonly used in classification of images. Neural networks consist of a number of neurons which are connected by links. Each of these links has an associated weight. Training of the network adjusts these weights, leading to a network which can accurately classify images according to their features [9].

A common hindrance in most of these image classification systems is the fact that the input into these systems are mainly vectors of features and not the pixels of the image. This means that an adequate feature extraction method needs to be constructed before the classification can be done. Deciding which feature extraction method is suitable for your classification model is experimental. This is one of the reasons why convolutional neural networks (CNNs) are considered one of the more accurate methods to do image classification as it takes the image as the input instead of the features of the image [10]. A disadvantage of CNNs however, is that they need a large amount of training data in order to become accurate in its classification [11].

3. TensorFlow

TensorFlow is an interface for creating and executing machine learning algorithms. It was built at Google and is released open source under an Apache 2.0 license [5]. The vast majority of TensorFlow is built in Python. There are a few aspects (such as image recognition) which have also been implemented in Java. In addition, some aspects have been implemented under Android.

CNNs are well adapted to perform image recognition. They were designed in a way which simulates human vision [12]. Most of the current classification techniques, such as HMMs and ANNs, do not take the pixels of the image as input, but rather a vector of features extracted from the image. This means that an adequate feature extraction method needs to be constructed before the classification system can be created. Deciding which features and which feature extraction method to use is experimental and could be timeous to complete. CNNs take the image as input rather than its features [13]. Unlike ANNs which consists of layers of fully connected neurons, CNNs are made up of convolutional, pooling, and fully connected layers.

Through the use of TensorFlow, a CNN can be easily constructed which can perform image recognition on a provided dataset.

A disadvantage of CNNs is the fact that they require large amounts of data in order to be trained adequately. This proof-of-concept was "trained" for large African mammals because large datasets of these animals are easily available. As is explained in subsequent Section 5. , obtaining the images with the appropriate licenses is problematic. For this research, images from Flickr (with a Creative Commons license) and from Image-Net (free for research purposes only) were used.

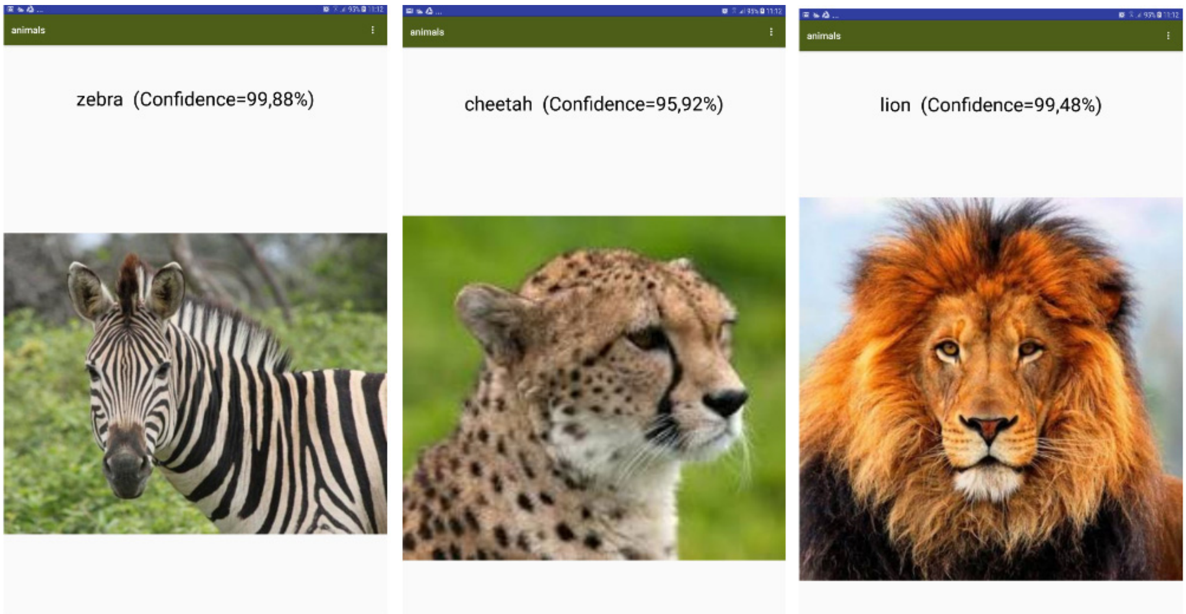
This proof-of-concept was “trained” for 36 different African mammals with over 25 000 training images. The system performs with an accuracy of 86%.

4. Android App

Once a TensorFlow model is trained and created it can be downloaded to an Android device. The app which was written for this proof-of-concept used the model which was previously trained on a desktop workstation. The app then allows the user to select photos from his or her Android gallery and check them against the model which was previously trained. As can be seen in Illustration 1, the model returned the animal name along with a confidence level which could be displayed to the user.

In this proof-of-concept, the model and its index were embedded in the apk as an Android asset. In a future release of the app, the model could be selected from the device file system. This would allow the one Android classifier app to work with various models. It would also allow the Android app to download different models or better models as they become available.

In addition, more information about the animals could be loaded on the device while the device has internet connectivity. This would allow the app to display other important information about the wildlife such as feeding habits (for carnivores), fruiting times (for plants), average speed (for prey and predators) etc.



It is important to note that once the model is downloaded to the device, then the app does not require an internet connection. The identification is done locally through the TensorFlow model and associated libraries on the device.

5. Possible Crowd Sourcing Platform

One of the biggest issues in the project (and in future similar projects) is sourcing sufficient number of photographs for training the TensorFlow model. As was mentioned in Section 2. , a high number of photos are required for training the TensorFlow model. There are a number of ways to source photographs including purchasing photographs and hiring photographers.

Photo crowdsourcing websites such as Flickr do have a large number of photographs with a Creative Commons license for the more popular African animals. However, at the date of writing this paper, for example, Flickr only had three Creative Commons images for a ring-necked spitting cobra (also known as a Rinkhals) which is common in southern Africa. That is not enough photos to train a TensorFlow classifier. Sites such as Image-Net have more photographs but they are strictly for research purposes and not for commercial purposes.

An organisation which wished to create a new animal or plant identifier using TensorFlow could first attempt to crowdsource photos from tourists or visitors to the area. This could be done through a simple website in conjunction with the organisation's website where tourists could upload photos, identify the photos, tag them with a Creative Commons license, and also, perhaps, tag them with a geo-location. Gamification techniques such as points, leaderboards, and badges could be used to drive the crowd sourcing of photos by awarding contributors. This could be done for a specific region or for a specific national park. Alternatively, an organisation such as bird watching club could attempt to crowd source photos of all the birds in a specific country.

The website could then start generating the TensorFlow models once per week or after every one hundred photos were uploaded and identified. The Android app described in Section 4. would be able to download new trained models as they become available and when the app is within an area with internet coverage. The possible architecture can be seen in Illustration 2. It is important to note that once the model is downloaded to the Android app, the app no longer needs internet connectivity. The Android app is 37 MB in size.

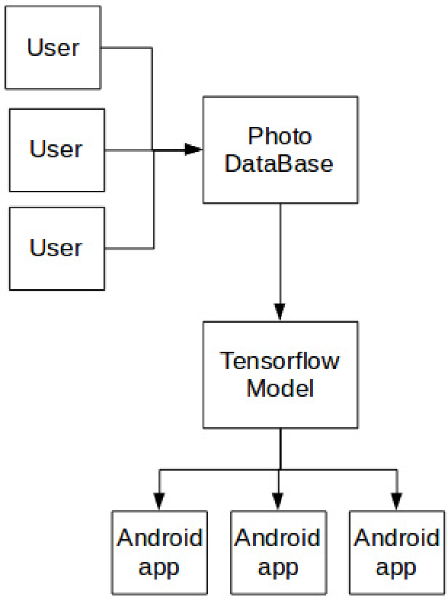


Illustration 2: Possible architecture

6. Business Benefits

Tourism in Africa directly contributes approximately 3% of the GDP on the continent [1]. One of the big attractions of Africa is the wildlife – both fauna (animals) and flora (plants). Tourists who visit to see the wildlife need supporting infrastructure such as hotels, bed-and-breakfasts, restaurants, petrol stations, and professional game rangers. Although the large national parks on the African continent have most of these facilities including professional game rangers who can assist tourists, many of the smaller parks do not have all these facilities. It is a catch-22. Smaller game reserves do not have all the facilities required; therefore, foreign tourists don't visit them. Because tourists do not visit the smaller game reserves, there is no need to build the supporting infrastructure. Thus the area surrounding the less known and smaller game reserves often do not benefit economically from tourism.

This paper did not attempt to solve all the problems of attracting tourists to less known game reserves. This paper only described on proof-of-concept to attempt to provide one of the missing pieces of infrastructure (game rangers) at less known game reserves.

By providing an offline app which can assist in identifying fauna and flora in such areas, the less know game reserves could have “virtual game rangers.” These virtual game rangers would be useful in attracting more visitors to the less known parks and areas. The side effect of this is that the surrounding area would have an increase in tourism. The new influx of tourists to the less known game reserves would still need to buy petrol, find accommodation, and buy food. This could bring income into previously underserved areas.

7. Next Steps

The app described in this paper was tested using two mechanisms: 1) testers downloaded miscellaneous images from the internet and used those images to test the app 2) testers actually used the app on a game drive in Pilanesburg National Park in South Africa.

Certain issues have arisen including the fact that animals often mingle with other animals (such as zebra and wildebeest) and the fact that many animals are only seen from a distance from the photographer and their images do not fill the entire photograph area. These concerns are being addressed in the next release of the app.

8. Conclusion

Tourism is a major source of income for many African countries. The areas surrounding major game reserves often economically benefit from tourism by providing accommodation, restaurants, auto-repair services, and petrol stations. The large game reserves also have professional game rangers available to assist tourists during their visit by identifying animals and sharing their knowledge. Because there are currently not many tourists at less known game reserves, there is also a shortage of professional game rangers at these smaller reserves. The surrounding areas then do not economically benefit from the game reserve since few tourists visit.

By creating a type of “virtual game ranger” using Google’s TensorFlow, these smaller less known game reserves could begin to attract more tourists by providing animal recognition facilities in an offline mode through the use of Android and TensorFlow. This means that areas surrounding such smaller game reserves could begin to economically benefit.

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