ISSN 1870-4069

Application of Machine Learning in the Development of Mobile Applications for Geographic Information Systems Using CreateML, CoreML and Mapkit for iOS

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Abstract. Applications of Geographic Information Systems (GIS) are found in Urban Planning, meteorology, Biology, Data science, etc. GIS is implemented in several technologies such as desktop, mobile, etc. Mobile applications are now important because of the mobility, and connectivity they offer. More GIS applications are now migrating to a mobility strategy. Additionally, there is a wide set of technologies we can use in the development of mobile applications for example for Operative systems like Android OS and iOS. In the case of Apple, it has developed an interesting ecosystem of Technologies such as ARKit for Augmented Reality, Virtual Reality that has become more popular with the Introduction of Apple Vision and the visionOS, Technologies for Artificial Intelligence like Create ML and CoreML, Map Kit is designed for the use of maps and its manipulation. The technologies behind these developments are. Swift UI and UIKit. Finally, the objective of this work is to describe a Framework to use technologies to create smart GIS.

Keywords: Machine learning, artificial intelligence, core ML, create ML, iOS.

1 Introduction

The use of Geographic Information System is used in every field of knowledge. For example, in [1], they mention that GIS is no longer solely associated with geography. Today we can find applications to GIS in social studies, artificial intelligence for example in spatial and qualitative reasoning, urban studies, and education, among other applications. On the other hand, technologies are become more sophisticated and miniaturized. We can have all the characteristics of a computer machine in our hands. One example is smart phones. In addition, there are a wide variety of applications that use components of a GIS. For example, the application Waze or Google Maps can be used to describe a route. Uber application is used for transportation of people, food, or delivery.

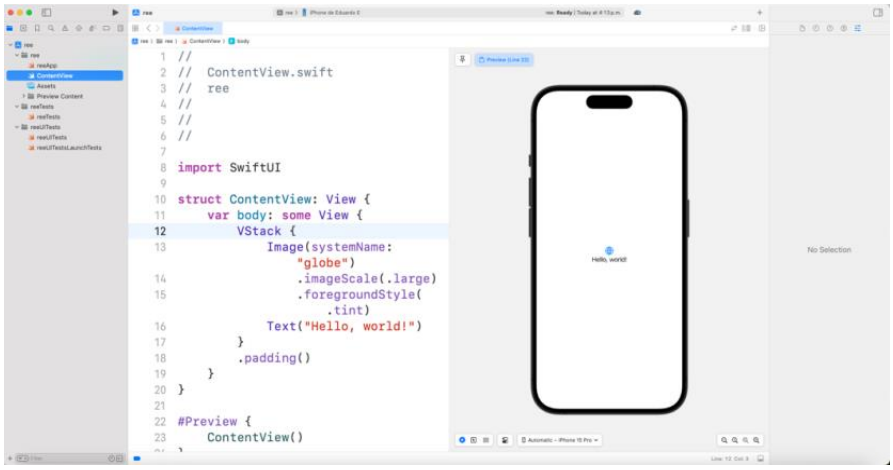

Fig. 1. XCode Technologies and Swift UI platform.

Mobile applications are now a growing environment where enterprises, organizations, and institutions can develop a solution or application to be more competitive. In the case of Apple, they develop a SDK (Software Development Kit). In the SDK developers can build useful, native applications. These libraries are Core ML and the set of applications that are Create ML and CoreML [3]. Core ML is a Machine Learning tool that allows training the machine to obtain a model that can be used with a specific purpose. Anode library is MapKit with a set of functionalities to describe maps and manipulate them [4]. XCode is a software where we can implement mobile applications using Swift Programming Language and Swift UI framework.

2 Related Work

Today the use of Geographic Information System (GIS) is beyond geography. The popularity of GIS is increasing thanks to its utility. Now we found GIS in social sciences, health, crime, climate change, remote sensing [5], etc. GIS is almost ubiquitous in every science field [1]. On the other hand, applications related to Artificial Intelligence are very common in literature, for example in [6], GIS and Machine learning are used to map minerals. The objective is to find potential targets where the mineral can be extracted (The article mentions some zones of China). In [7] artificial intelligence is used to simulate avalanches to prevent tragedies. Finally, [8] shows the importance of preventing vegetation vulnerability by monitoring and predicting.

On the other hand, the rise of mobile applications allows to implementation of a variety of applications in a smartphone. For example, in [9] mobile applications are useful in the event of disasters. In [10] the work shows the integration of GIS into mobile applications. Finally, as we see, there is an evolution of GIS applications to mobile applications, sometime because their portability and computer power.

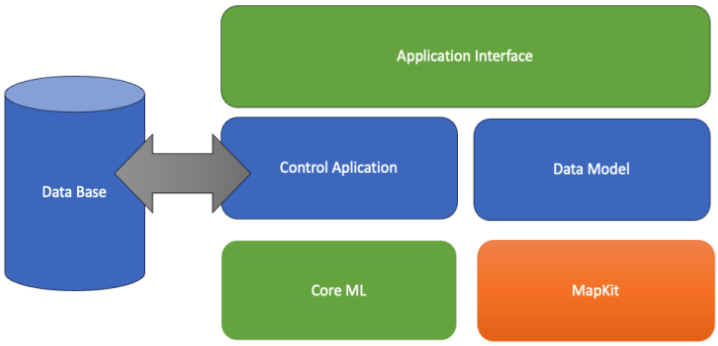

Fig. 2. Proposed architecture.

3 Proposed Architecture

The proposed Architecture is showed in fig 2. The architecture is based in Vista Controller Model where elements are divided in areas of functionality. The first layer is recommended to design the application interface, and the functionality of the buttons. Then we define the application control where we model the communication between the Database, and the components necessary of the GIS Application, for example if the applications need an implementation of Map GIS to show data on a machine learning model whether an artificial intelligence is needed. Finally, we require a block where we can model the data of the application.

3.1. Application Interface

The application interface is defined according to the design proposed in [11]. Where the process of designing and panning is divided in four stages: Brainstorm, Plan, Prototype and Evaluate. Fig 3 shows the cycle of development of a mobile Application.

– Brainstorming. Allows us to identify different problems and propose a solution. This stage prepares us to configure the elements that an iOS application needs to address.
– Planning. Is the stage where we can describe step to step the details of the solution and the means to achieve a goal.
– Prototyping. In this stage, we create a visual example of the application. Usually to our users. The idea is to receive feedback from our users and all the stakeholders in the project.
– Evaluating. Allow us to present the applications to several users in order to find possible errors.

Fig. 3. The design Cycle taken from [11].

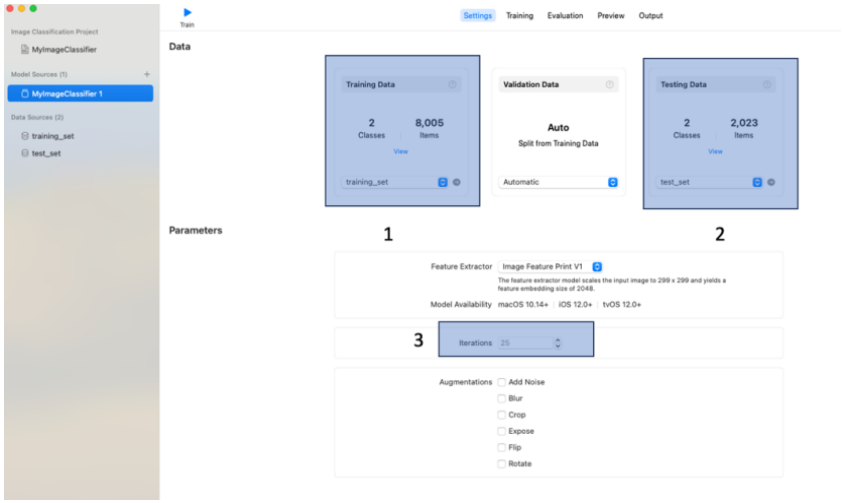

Fig. 4. Create Model window, section of training.

3.2. Control Application

Core ML is a technology that allows to produce machine learning models to process images, and video, capture motion, identify sounds, text recognition. To create a model it is necessary to use Create ML. Create ML is a tool that permits to generate models for hand pose classification, object detection, image classification, text classification, word lables among other applications.

Later Create ML generate a model (with ml file extension) that can be added to the main application in XCode. Suppose for example we would like to identify cats from dogs, in figure 4 we can see the main window where in section 1 is added all the images necessary to train the model. In section 2 it is necessary to add the image required for the training stage (Note the validation data is set in auto). Finally, in section number three we specify the number of epochs required to train the model and minimize the error.

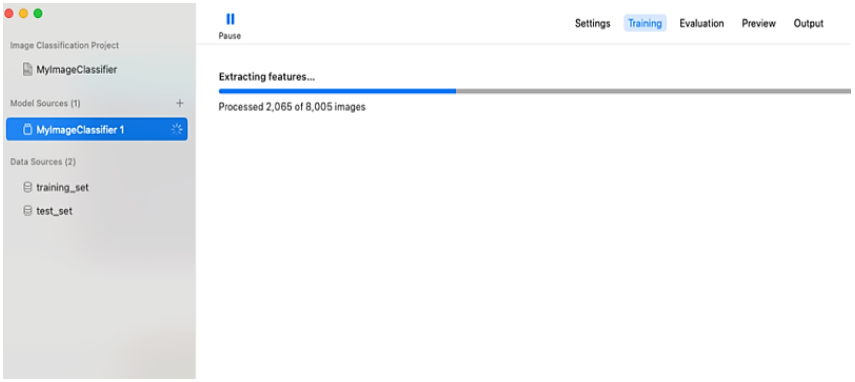

Fig. 5. Training process of the model.

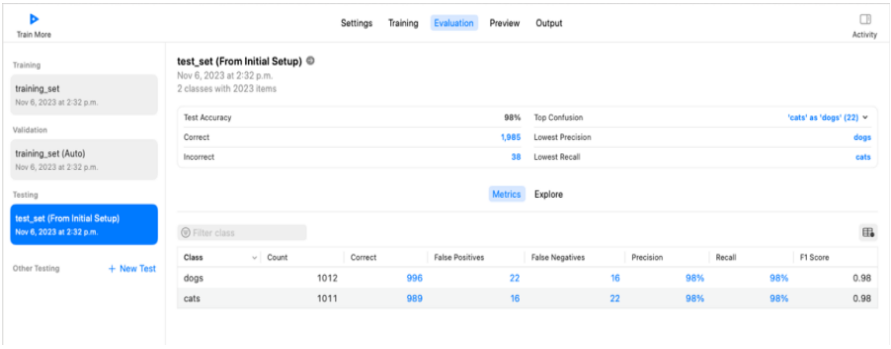

Fig. 6. Results of the training process.

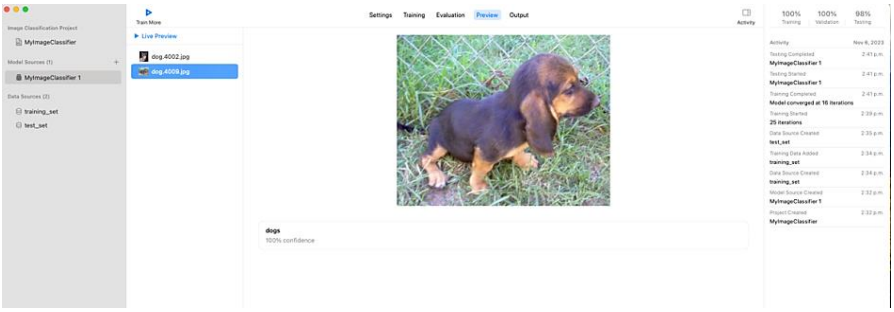

Fig. 7. Preview mode.

Later in Fig 5, We can observe the training process. It is worth mentioning that thanks to Apple technology and the set of processors M2 [12], it is possible to train a model using a very reduced amount of time. Then in Figure 6 we observe the results of the training model. We can see important information such as the accuracy of the model and other important metrics such as recall and F1 score. Finally, in figure 7 we can add any image and test the model. Finally, we can export the model to add it to our Project folder in XCode.

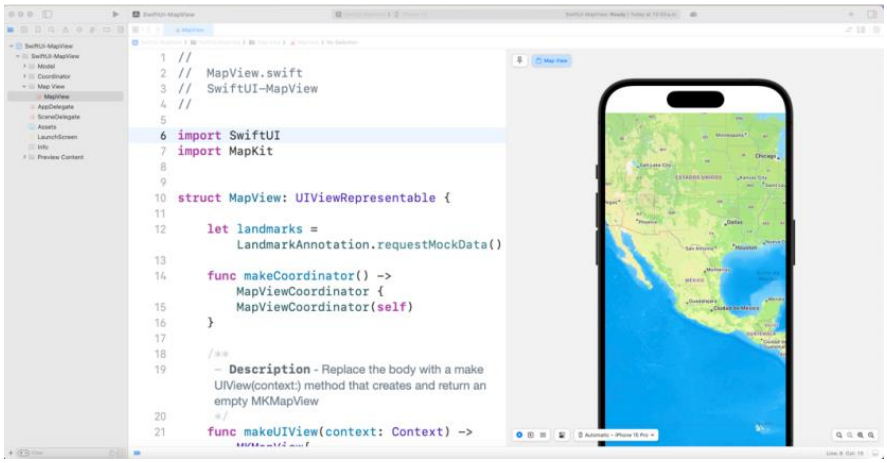

Fig. 8. Mapkit Framework.

3.3. MapKit

Finally, Mapkit is a technology that can accept structure types like Jason, GEO Jason in the case of spatial. Additionally, can detect the geoposition. Mapkit framework also permits adding maps, annotation, responding to user interactions, providing text completion [4], and now is integrating with ESRI [13].

3.4. Integration with GIS

GIS is important in a variety of science fields, for example Economy, Meteorology, Civil Engineering, Architecture, Computer Science, Social Studies, etc. According to [Introduction to GIS], the key components of GIS are:

Software: Necessary to implement algorithms, tools, methods, etc. The development of this branch are need and more types of software from standalone applications, web applications, and now mobile applications. Additionally, the present requirements need to add elements of artificial intelligence, computer graphics, etc.

– Data: Data is the most important feature of this century. Now data drives the operation [14]. Data needs to have a format and require to be complete, correct, and precise. Sometimes need to be preprocessed to be scaled or transformed.

– Protocols: Protocols are necessary in GIS to describe the data entry and updating.

– Hardware: It is necessary to consider the magnitude of the applications, according to it the use of memory, and interfaces.

– People: GIS identified different types of users, and experts, with no knowledge.

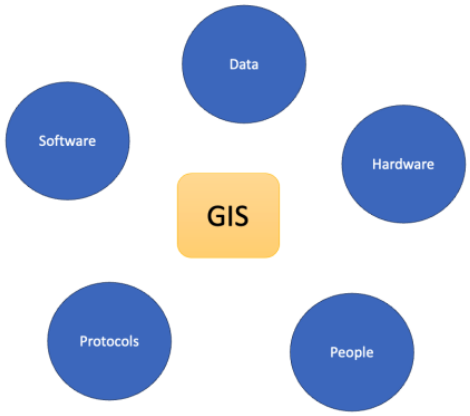

Fig. 9. Key Components of GIS.

Finally, to resume the component software is constantly updating. So it is necessary to implement ad hoc technologies and methodologies. In this case, ways to implement GIS in mobile applications using iOS technologies. In Addition to that Data needs to have a data model ad hoc to the iOS applications format. Protocols need spatial implementation according to the design of the application. The hardware needs to be implemented in iOS using native programming because of the particularities of the Apple Hardware. Finally, is necessary to have developers specialize in Swift, Objective-C and XCode.

4 Conclusion

The development of a mobile application needs to be measured in weeks, or months. The development time is getting shorter every day. Technologies needed today to build an application are becoming more sophisticated. It is important to have prebuilt frameworks, and libraries to develop in time.

Additionally, it is important to have an architecture to integrate all different technologies to identify different functionalities an application needs to implement. For example, a stage where the design of the application needs to be separated from the technologies that can be implemented for example Machine learning (MapKit) and display maps and different elements. MapKit is a robust technology developed by Apple that allows the addition of different functionalities a GIS has. On the other hand, machine learning is a recurrent topic that is often implemented in all kinds of applications. Create ML and CoreML help us to add interesting applications the application needs to implement.

Acknoweldgments. The authors would like to thank to Universidad Nacional Autónoma de México, Facultad de Estudios Superiores Acatlán and DGAPA-UNAM (PAPIME PE305523 and PAPIME PE 301521) for the funds to support this work.

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