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Satellite Image Change Detection using U-Net Model

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Abstract - *Remote Sensing is used widely for geographical observation of large areas on earth than traditional techniques like on-site inspection, drones owing to its wide range, less cost, and minimum time. Change detection is an important application of satellite images. In this project, we attempt to design a deep learning model for detecting changes between two satellite images of the same geographical area over time. The solution takes two satellite images of the same region but different time zones as input and highlights the geographical changes that took place over the period of time. The highlighted changes will be in terms of terrestrial as well as area metrics. Thus, our system provides a complete solution and overcomes the limitations of existing geographical inspection methodologies. Change detection is very helpful in research, disaster management, academic projects, and also in the important sectors like defense. This report carries out a literature survey of previous papers that addressed the same concern and also studies the methodology proposed by different authors.*

Key Words: **Remote Sensing, Change Detection, Deep Learning, Image Segmentation, U-Net Model.**

1.INTRODUCTION

Satellite data is the data collected by manmade satellite of earth and space. Satellite images are commonly used in Earth Observation. Useful information about the surface and weather changes is delivered by the satellite. One of the inherent values that satellite data has is the availability of authentic information about Earth's surface, weather, and other incidents. Cumulative data helps to understand developments in long-term and timely data to act swiftly on the detected issues. The number of satellite data applications is unlimited, providing manyfold advantages on a global and local scale. The data about difference between two satellite images is important for various evaluation like geographic observation, climate change research. Satellite imagery can be used in the categorization and monitoring of land into different categories, such as different types of land uses and land cover.

Change detection is an important application utilizing remote sensing images. It provides the changes that have occurred on the Earth's surface by processing two (or more) images acquired at different times that cover the same geographical area. This data allows scientists, businesses, and the government organization to examine an area over a time and observe the changes, Deforestation, Polar ice loss, and Climate Change study all make use of change detection techniques using satellite data to monitor their particular fields. The rate and extent of forest loss and ice melt can be tracked, as well as overall trends of change in our world's climate.

There are many existing methodologies used for carrying out change detection of satellite images such as image differencing (ID), image rationing (IR), principal component analysis (PCA), change vector analysis (CVA), expectation-maximization (EM), graph cut, the Parcel-based method and Markov random field. The disadvantages of these methods are in choosing an appropriate threshold. However, this method does not extract the details of the changes completely. The manual change detection can be carried out but it consumes a lot of time. The precision and accuracy are highly subjective depending on the expertise of the analyst. Hence, the need for automated methods for such analysis tasks has emerged and thus gives rise to unsupervised machine learning algorithms.

In this project, we propose a method to generate the Difference Image to highlight the differences between two temporally different images of the same scene. The generated difference image is analysed to determine the class of changes. The satellite image may be affected by negative effects of reflectance values, techniques such as radiometric correction are usually applied in the DI creation. CNN has been used to generate a different image. In this project, we construct a UNET model for effective semantic segmentation of the input images. The proposed methodology aims to overcome the limitation of existing techniques of change detection.

1.1 Objective and Purpose

In usual scenarios or in the ongoing technological world, satellite images play a very important role. We can have the present idea of the geographical conditions of a particular location and even the prediction of future is possible through these images. The sole purpose of this project is to ease the work of change detection through deep learning models instead of the manual process (which is the current practice going on). Many mistakes are bound to happen when a human observes through naked eyes. Instead, when a machine processes two images and then creates a 'Difference Image' then it has a very low chance of making mistakes. One can have so many geographical predictions through these 'Difference Images' of the same location but of different time zones. The purpose is to save time and money which goes behind all this process and to build an efficient system which will help humans to detect changes just by sitting in a closed-door office.

1.2 Background Study

The current processes of change detection are expensive, time-consuming and are not that efficient. Over the years, a wide range of methods have been developed for analysing remote sensing data and newer methods are still being developed. Change detection of Earth's surface provides the basis for evaluating the relationships and interactions between human and nature for better resource utilization. This paper provides efficient and least expensive method for change detection. The study also gives a brief account of the main techniques of change detection and discusses the need for development of enhanced change detection methods.

2. PROPOSED SYSTEM

The project requires semantic segmentation of the satellite images. There are various objects in the satellite images. The model requires sufficient amounts of the data to be trained for each image therefore we are focusing on the urban area like trees, rivers, houses and land areas for change detection. The collect dataset is well suited for the scope of the project.

2.1 Change Detection

Change detection is a method that evaluates how a area has been changed over a period. The primary source of data is geographic and is usually in digital format, analog format, or vector format. Ancillary data can also be used. Change detection often involves comparing satellite images of the same area taken at different period. Change detection has been extensively used to evaluate farming, deforestation, urbanization, tsunamis, earthquakes, and use/land cover changes, etc. This data allows scientists, businesses, and the government organization to examine an area over a time and observe the changes. The rate and extent of forest loss and ice melt can be tracked, as well as overall trends of change in our world's climate.

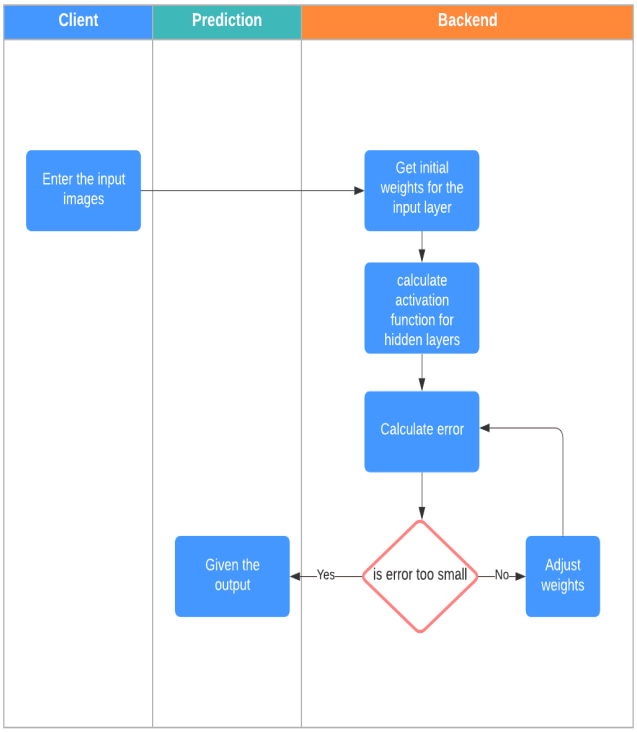

Fig -1: Activity Diagram

2.2 U-Net Model

O. Ronneberger et al. have taken forward the FCN of J. Long et al. for biological images. The authors developed u-net network in two parts: a contracting part that computes feature and an expanding part to spatially localized patterns in the image. The down-sampling part has a FCN-like architecture extracting features with 3x3 convolutions. The up- sampling part utilizes up-convolution decreasing the number of feature maps while extending their height and width. It doesn't use any FCN layer. Which results in the number of parameters of the model to be decreased and it requires very less amount of data for training.

2.3 Data Collection

There are four types of resolution when discussing satellite imagery in remote sensing: spatial, spectral, temporal, radiometric, and geometric. The correct type of satellite images suitable for our requirements must be selected. The dataset will be used to train the model for image segmentation. The dataset should be properly annotated. The data should cover all the necessary classes on the earth's surface.

2.4 Data Pre-processing

Due to the complex and heterogeneous nature of satellite imagery, even within categories, classification of land use within satellite imagery is a daunting task. Moreover, high-resolution satellite imagery are used to store, transport, change, and performing complex learning tasks on such high-resolution images becomes complicated as it runs into network and memory issues. So, the data must be pre-processed using required techniques such as geometric corrections, radiometric correction, etc.

2.5 Change Detection Approaches

There are mainly two approaches to perform change detection i.e. post-classification analysis, or difference image analysis. In post-classification change detection first, two satellite images are labelled, then compared to identify the differences. The precision of change detection depends on the accuracy of the classification of two images. In pre-classification, a Difference Image is constructed to highlight the changes between two satellite images. The difference image is then analysed to identify the class of changes. The best method must be selected. The approach must not use many resources and should provide good accuracy.

3. Implementation

The system first takes two satellite images as inputs. The two images are semantically segmented using U-net model. The images are segmented for various geographical features. The segmented image mask is then processed two obtain difference of the two images using image processing. The output image contains the differences between two images highlighted in different colors.

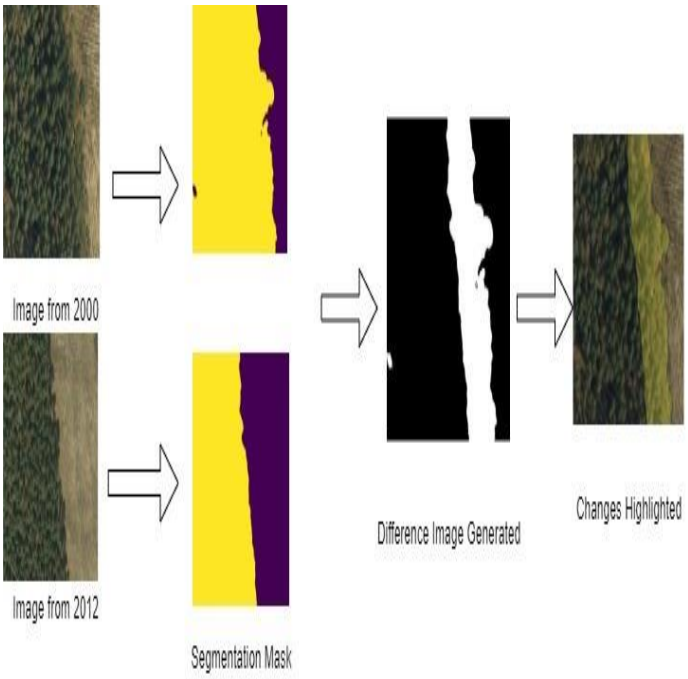

Fig -2: Working of system

4. CONCLUSION

The paper established the use of deep learning models in satellite change detection. Satellite image provide a lot of information about the land cover of an area. Sometimes it becomes difficult for human to reach so satellite images are helpful in such cases. The U-net model was developed to be trained on satellite images. The model was successfully trained with an accuracy of 90%. The solution provides better visualization of the changes occurred. It helps the user in monitoring the land and extract useful information.

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