Semantic Enabled Cloud for Satellite Meteorological Data Processing

Submitted By

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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NIRMA UNIVERSITY

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Semantic Enabled Cloud for Satellite Meteorological Data Processing

Major Project

Submitted in partial fulfillment of the requirements

for the degree of

Master of Technology in Computer Science and Engineering

Submitted By

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Guided By

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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May 2015

Certificate

This is to certify that the major project entitled **"Semantic Enabled Cloud for Satellite Meteorological Data Processing"** submitted by **Somil Gadhwal (Roll No: 13MCEN24)**, towards the partial fulfillment of the requirements for the award of degree of Master of Technology in Networking Technology (CSE) of Institute of Technology, Nirma University, Ahmedabad, is the record of work carried out by him under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this project, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

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Statement of Originality

I, **Somil Gadhwal**, Roll. No. **13MCEN24**, give undertaking that the Major Project entitled "**Semantic Enabled Cloud for Satellite Meteorological Data Processing**" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in **Computer Science & Engineering** of Institute of Technology, Nirma University, Ahmedabad, contains no material that has been awarded for any degree or diploma in any university or school in any territory to the best of my knowledge. It is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. It contains no material that is previously published or written, except where reference has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

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Date:

Place:

Endorsed by

Prof. Swati Jain

(Signature of Guide)

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- Somil Gadhwal

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Abstract

Meteorological data is being captured regularly by our satellites. It can be utilized in multiple ways to obtain useful predictions and meaningful information. This domain contains many applications specific to user's demand such as rainfall prediction or solar prediction , but a generic framework is needed so that every application can be combined under one platform. This work involves huge amount of image processing and deploying some prediction and estimation mechanism which are extremely compute intensive. So this architecture is deployed on cloud computing for utilising resources efficiently and smartly.

Abbreviations

MATLAB	MATrix LABoratory.
MOSDAC	Meteorological and Oceanographic Satellite Data Archival Centre.
AVHRR	Advanced Very High Resolution Radiometer.
SWIR	Short-wave infrared
HDF5	Hierarchical Data Format

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Chapter 1

Introduction

Weather prediction has been a popular and necessary importance in our daily life. Specially in the regions where food and flora highly depend on natural resources like India. To estimate weather accurately is todays necessity. Since now many technology and models have been proposed to take this method to higher level but still accuracy is an important issue. The basic issue in urban regions is expanding surface temperature because of change and transformation of vegetated surfaces to impenetrable surfaces. These changes influence the absorption of sun powered radiation, surface temperature, evaporation rates, storage of hotness, wind turbulence and can radically change the states of the close surface air over the urban areas[1] So we need a reliable weather prediction system that can help in making common life safe place to live.

1.1 Background

Weather forecasting is a branch of science that is used to predict environmental condition. A few techniques have been contrived to foresee climate physically by recording the example . Presently a days climate figure are made logically by recording past information and providing for it as data to the calculation or the strategy.The components involved in this projects are as follow.

1.1.1 Image Processing

In imaging science, image processing is any manifestation of sign processing for which the info is an image, for example, a photo or feature outline; the yield of image processing may be either an image or a set of attributes or parameters identified with the image.

Most image-processing methods include treating the image as a two-dimensional flag and applying standard sign processing systems to it. [2].

1.1.2 Semantic Cloud Computing

The business sector of

cloud assets is still in its early stages because of, in addition to different reasons,

the absence of interoperability among existing cloud stages[3]. Cloud gives an accessibility and execution however with this comes manual task of Virtual machine assets as indicated by the need of use. this make a trouble over the programmer so to stay away from this, cloud is given semantic force to choose ideal assets all alone.

1.1.3 Weather Forecasting

Weather forecasting is the application of science and engineering to foresee the condition of the environment for a given area. Individuals have attempted to anticipate the atmosphere easily for a considerable length of time, and formally since the nineteenth century. Climate gauges are made by gathering quantitative information about the current condition of the environment on a given place and utilizing exploratory understanding of environmental techniques to extend how the air will develop on that place[4]. Weather forecasting is of several types-

1. Persistence Forecasting - Persistence forecasting is focused around the idea that current climate conditions can uncover hints to tomorrow's estimate. Meteorologists who rely on upon this assessing strategy predict that current conditions will hang tight, or move ahead unaltered. They mention objective facts utilizing thermometers and gauges to survey the climate, then hypothesize that the following few days will emphasize comparable climate designs.

2. Statistical - Statistical or climatological forecasting permits meteorologists to make forecasts focused around historical patterns. It acknowledge unsurprising atmosphere plans after sooner or later. Forecasters take a gander at unquestionable information about normal, high and low temperatures to gage future temperature ranges.

3. Computer Modeling - Machine demonstrating forecasts speak to the most progressive technique for foreseeing the climate. This system relies on upon investigative

formulas that are proposed to model barometrical and atmosphere conditions. By inputting current atmosphere information, the meteorologist can figure future conditions.

1.2 Motivation for this Project

Meteorological data is used for weather prediction and this involves image processing through which each and every meteorological application can be implemented.The area of meteorological application is tremendous, for example, Clear sky transmittance in which The recognition and recognizable proof of convective cloud seems, by all accounts, to be a key venture currently expectation of precipitation [5]. Convective mists can be recognized from warm infrared pictures (TIR) as mists are connected with low temperature and consequently they seem light in TIR pictures [6]. Generally Infra red images are used because Infrared thermo graphy provides images (thermo grams) in which zones of interest appear sometimes as subtle signatures due to all factors that degrade infrared (IR) images from self-emission of the IR camera to the nonuniform properties of the surface where data are collected[7]. However Image preparing is process concentrated. So as further bolstering increase the good fortune of mists accessibility and execution and to perform continuous computation, we utilize Semantic Cloud. Fig 1.1 shows need of unified platform.

1.3 Objective of Study

The main objective of building this application is to provide the user independence to build any application of their own use so that we are spared with additional calculation and results are more application oriented which will save time and space. The first two component of the application i.e. application building and and ontology algorithm are handled here.

1.4 Scope of Work

The generic application will provide a platform to the user to build application that is demand specific and the resources used are also optimum. For this we need Satellite dataset that provide us with multispectral images and meta data. This dataset is used as input for the application. The desired dataset and the flow of application chooses the

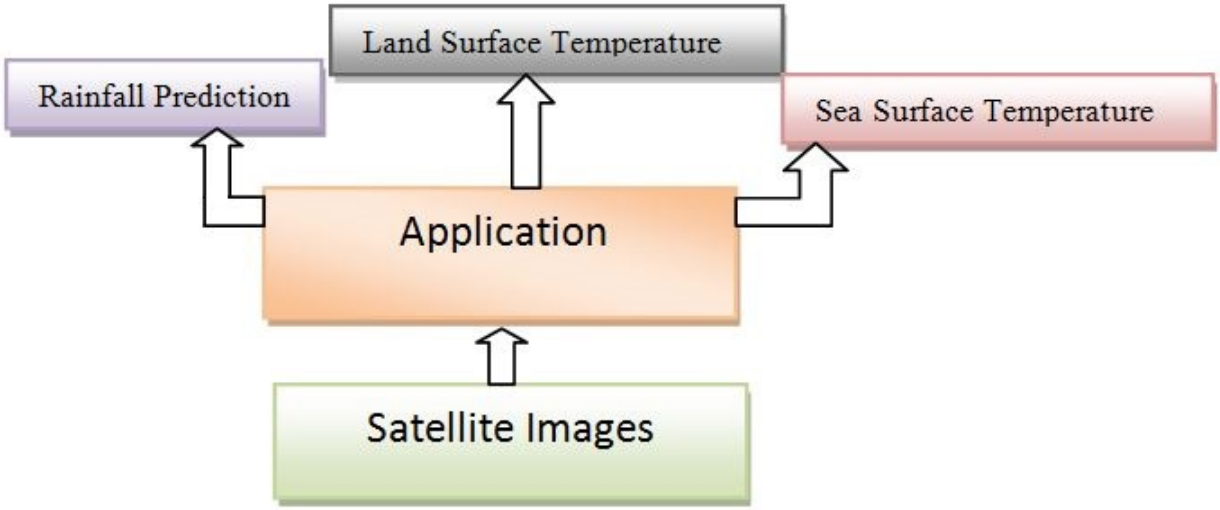

Figure 1.1: Use of application in other weather prediction techniques

resources required to form a semantic cloud and this results in a optimum environment that uses resources efficiently and provides high computation power.

Chapter 2

Literature Survey

2.1 General

In Literature survey, I referred many papers relate to image processing, satellite data processing . In general these paper gave me an insight to the domain or application of Image processing and satellite data processing also provided approaches to implement satellite data processing using image processing efficiently.

2.1.1 Digital Image processing

Digital image processing is the utilization of machine calculations to perform picture preparing on computerized pictures. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing. Picture preparing is utilized for creating information and Meta information utilizing pictures of satellite and produces conclusion as needs be. Without any sensor systems, this can end up being help throughout today's engineering. The concept of Using more than one computation resource for solving certain time consuming problems seems more interesting and valid. [8].

2.1.2 Parallel Image Processing

Fast picture preparing is need of this application. This can't just attained by expanding the assets, however parallel picture transforming evacuates the bottleneck of rapid picture preparing.The processing of large neighborhood image is currently the bottleneck of high speed image processing, which hinders further application and development of image processing algorithms [9]

2.1.3 Remote Sensing

Remote detecting is the procurement of data about an article or sensation without reaching the item and in this way rather than on location perception. [10] Data form satellite comes in two different forms 1. Raster 2. Vector. Many remote-sensing satellites can obtain images in multispectral and panchromatic bands[11] Raster data structure is based on periodic repetitions of of 2D plane into cell. Advantages of using this scheme is that it is more compact and easy to visualize. But the disadvantage of using this scheme is it leads to loss in information. To overcome this problem, Vector Data is used.

Satellite Imaging results in large amount of data set. It is difficult to group the data into a hierarchical manner, so HDF5 is used generally. It is designed for scientific data consisting of data set and attributes (or Meta data). Advantage of using HDF5 data set are as follow

1. Directories and Flies - hierarchical collection of related information
2. Database - Random access sub setting.
3. Binary Flat File - High performance.
4. XML - self describing, rich meta data.
5. PDF - Standard exchange format.

2.1.4 Multispectral Images

Images that contains more than 1 band are called multispectral images. Multispectral pictures are the primary sort of pictures gained by remote detecting (RS) radiometers. Separating the range into numerous groups, multispectral is the inverse of panchromatic, which records just the aggregate power of radiation falling on every pixel. Ordinarily, satellites have three or more radiometers (Landsat has seven).

2.1.5 MATLAB and Multi core environment

MATLAB alone ia a multithreaded application. It provides parallel computing environment using explicit multithreading. To Matlab provides several toolboxes such as Image processing toolbox that is used to process images and can perform valuable computation with minimum time overhead. It also provides Parallel computing environment.

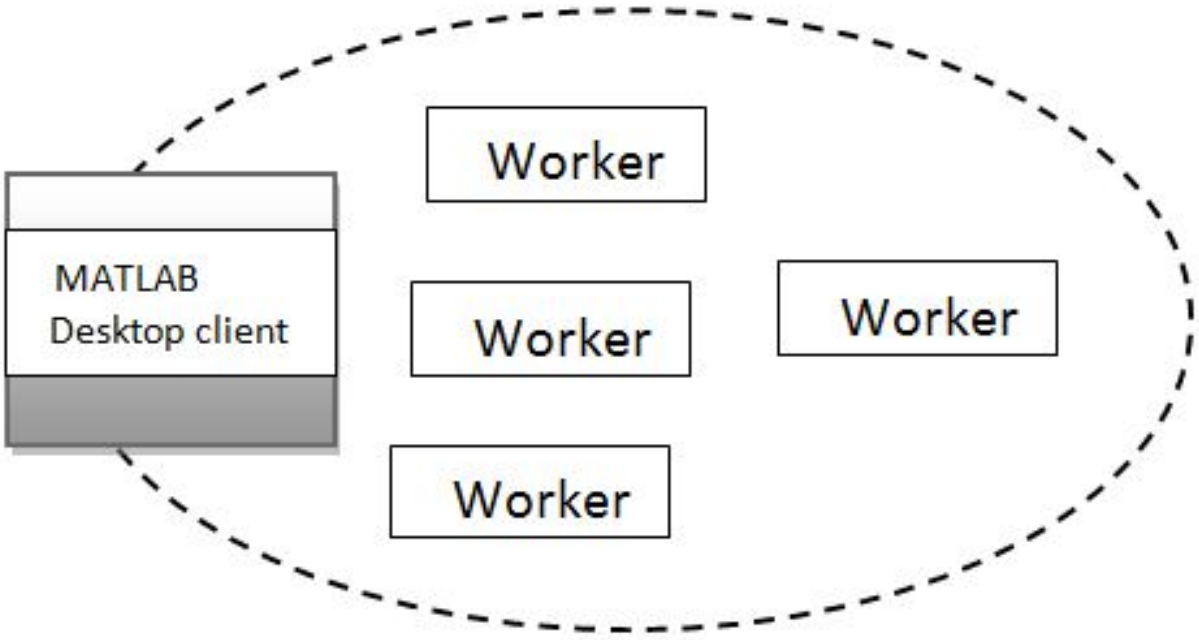

Figure 2.1: MATLAB multicore environment

Matlab provide Parallel processing Toolbox [12] to compute data intensive problem in multicore processor, GPU and computer cluster. Data is parallelized using parallelized algorithms, dedicated arrays and parallelized for loop, that gives a user freedom to efficiently distribute the data without the burden on managing it. Parallel application can be executed in interactive or batch mode. Matlab provides easy and efficient way to for compute image processing task involved in satellite image processing. Several other toolboxes are GUIDE (GUI Development Environment) that allows a user to create GUI using drag and drop facility and background function.

2.1.6 Need of Multi Core Environment

With the continuous growth of complexity of programming, it has been difficult now to increase the performance by scaling clock speed further. To meet this demand, modern System-On-Chip solutions contain multiple processing cores. Reason behind using multicore programming is

- Can make use of various kind of parallelism.
- Decrease power consumption.
- Effectively hide memory latency.

- Resources are utilized more effectively

In MATLAB workers are able to communicate with each other as well as the client. Client create work to do for workers.So parallel processing uses these workers. "It uses Parallel Computation Toolbox" it solves computation and data intensive problem using multicore processor.

2.1.7 Need of Cloud masking application

Weather prediction can be done using various measures, satellites are also used to capture data in the form of multispectral images and these images are used to extract information about the temperature of the area. Reflectivity for solar energy is more by clouds in comparison to land hence it is possible to distinguish the cloud from land using thresholding, however it is not always possible to obtain a global threshold. They vary according to the temperature of the surrounding area and the also on the time i.e. day or night. If this model is used for energy budget prediction in solar energy conservation then this error may lead to day to day energy needs.

2.1.8 Need of Land Surface Temperature

The genuine variability of how warm or chilly the air gets relies on upon numerous elements. The best figure deciding the air temperature is the measure of sun powered radiation that achieves the surface. The real variability of how warm or frosty the air gets relies on upon numerous elements. The best figure deciding the air temperature is the measure on solar radiation that achieves the surface- -that is, the information of vitality from the sun and the yield of vitality from the surface. So measuring Land temperature is important in order to predict weather condition on land surface. Brightness temperature is the temperature that a person feel when earth's temperature is touched. It is different from air temperature.

Chapter 3

Proposed Architecture

3.1 Proposed Architecture

3.2 Approach for Project

Several steps will be needed -

3.2.1 Data Set Accumulation

Downloading Meteorological data set from MOSDAC website that contain parameter and imagery that contains multi spectral images.The data set is available from Meteorological and Oceanographic Satellite Data Archival Centre in short also termed as MOSDAC [13].Several satellites like KALPANA-1 ,INSAT-3A, MEGHATROPIQUES ,INSAT-3D are available that provides Imagery and Sounder data of earth [14].We are using INSAT-3D data which include Standard and Geophysical Parameters provided in HDF5 (Hierarchical Data Format version 5)Format [15].Fig 3.2 shows satellite image showing cloud data.

3.2.2 Band Extraction

Band Extraction Spectral Data from the satellite comes in an HDF5 format. This hierarchy that is converted into bands so as to extract a band that serves the purpose of providing radiance value for that particular pixel.These steps involves initialization of the data and its further processing.The data is available with several parameters in several bands such as Shortwave infrared, Visible region etc. these bands are extracted according to the use of application for example VIR band is used for land-sea surface

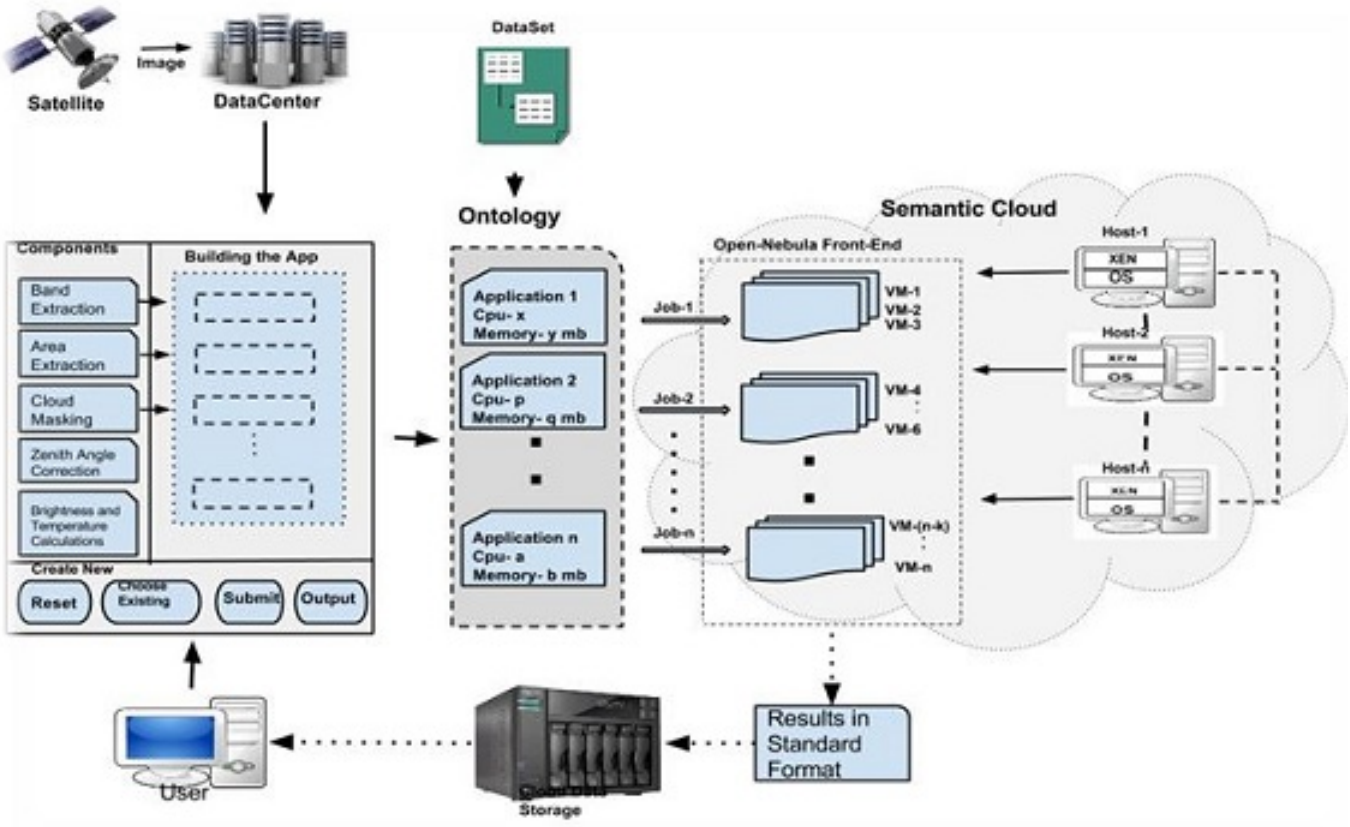

Figure 3.1: Proposed Architecture

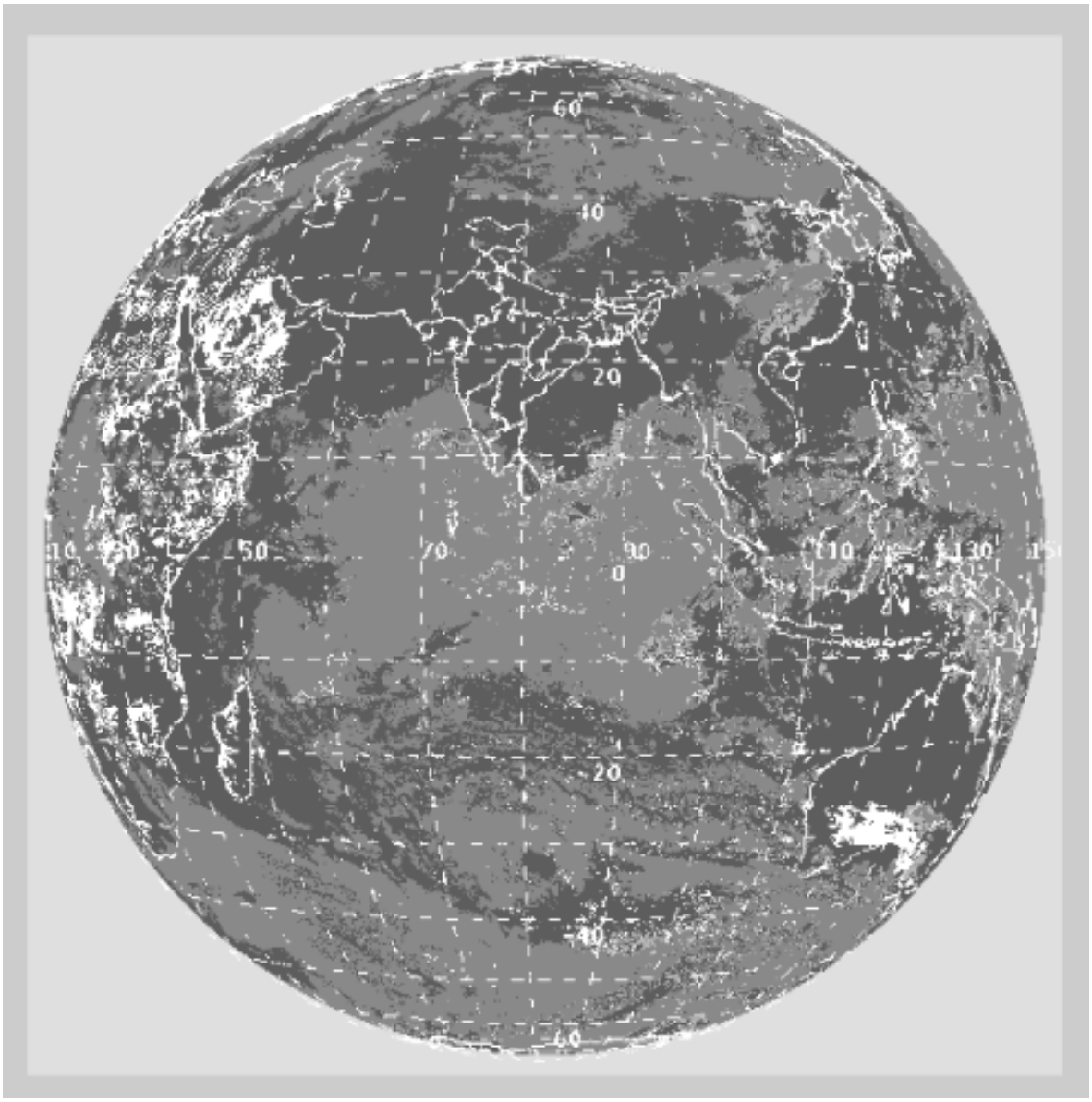

Figure 3.2: Satellite Image showing cloud mask

discrimination. A single band or multiple bands can be used in an application.

3.2.3 Building Modules

Several modules are build individually and data set is used to process these modules, latter they are combined in a common platform to provide a user interface.The modules are as follow-

1. Area Extraction-The information of latitude and longitude is available with most of the data set but each product have different scale of the are The user needs to choose the area for which he/she wants to run a particular application.In this , a particular area is chosen from the drop down list and a mask is created which contains a binary image that have ones in the selected area and and zeros in rest of area so that results are specific to that area and computation resources are saved.other information related to that area such as longitude, latitude, pressure etc is also loaded for further use. In order to extract same area from different scaled images provided by the satellite, a mask of every state is saved by using a scaled mapped that have defined boundaries. whenever a state is selected, its mask is invoked and scaled according to the data set used. By this we can have exact boundary specifications and can reduce estimation errors.

   However area for temperature is calculated by using latitude and longitude information given by the user. It not only increases the accuracy and precision but also decreases the error due to false region

2. Cloud Masking-Clouds are by and large described by higher reflectance and lower temperature than the basic earth surface. All things considered, straightforward unmistakable and infrared window edge methodologies offer extensive expertise in cloud location. In any case, there are various surface conditions when this characterization of fogs is awkward, most strikingly over snow and ice. Also, some cloud sorts, for example, meager cirrus, low stratus during the evening, and little cumulus are hard to catch be-reason for lacking stand out from the surface brilliance. Cloud edges causes further difficulty since the instrument field of view will not always be completely cloudy or clear. For each band, visual discrimination of clouds allowed the histogram of their reflectance values to be determined.A preliminary threshold

to separate cloud from land and ocean features was determined based on the minimum reflectance value of the cloud histogram. However this method is an issue under specific conditions as thresholds are never global.

INSAT 3D VHRR data set offers five radiance bands, one SWIR band, one visible band, one WV(Water Vapour) band and two TIR bands. For cloud mask, we use three IR bands, TIR-1, TIR-2 and MIR. Using these three bands, cloud mask is created that uses BT Threshold Algorithm [16]. Using this algorithm , INSAT provides a CMK data set that gives the mask of the cloud in full disk area of the earth.The data set can be interpreted as

Output of cloud Mask (Scan per pixel)
0=Pixel is clear
1=Pixel is cloudy
2=Pixel is probably clear
3=Pixel is probably cloudy
9=Region out of disk space

Using this algorithm, and the mask generated in previous step, the algorithm is implemented only on that particular area chosen by the user and ratio of the pixels are calculated. The highest ratio is predicted as the weather condition for that particular area.

3. Brightness and Temperature- In order to estimate the surface contribution we calculate the top of atmosphere clear-sky images. Since surface temperature varies significantly both diurnal and seasonal, we calculate surface emissivity instead as surface contribution. Surface emissivity varies with wavelength, soil type and moisture content, and vegetation type and condition as well as viewing angles. Because of these dependencies, the spectral variations of the surface emissivity are important for remote sensing of aerosols and retrievals of their properties. Surface emissivity is calculated by solving a set of equations to obtain the surface skin temperature that is required to calculate the surface emissivity we need observations from both daytime and night time over the same area.

   The Land Surface Temperature (LST) is the radiative skin temperature of ground. It relies on upon the albedo, the vegetation spread and the dirt dampness. By and

large, LST is a blend of vegetation and uncovered soil temperatures. Since both react quickly to changes in approaching sun oriented radiation because of shadiness and vaporized burden alterations and diurnal variety of enlightenment, the LST shows fast varieties as well. Thus, the LST impacts the segment of vitality in the middle of ground and vegetation, and decides the surface air temperature.

Area surface temperature, a key marker of the Earth surface vitality spending plan, is broadly needed in uses of hydrology, meteorology and climatology. It is of basic significance to the net radiation spending plan at the Earth's surface and for observing the condition of products and vegetation, and an imperative pointer of both the nursery impact and the vitality flux between the climate and earth surface.

INSAT 3D Imager Land Surface Temperature(LST) data has been used which is downloaded form MOSDAC website. This data uses several bands,split thermal window channels (10.2-11.3m, 11.5 12.5m) during daytime and using additional mid IR 50 window channel (3.7 4.1m) during nighttime over cloud free [16]. Every pixel contains temperature value, which can be used to calculate temperature over a region.

4. Resource Calculation - This module calculate the amount of data that will be used in the computation and also number of application so that VM allocation .

5. Web- This module initiate a web activity that direct to a websitethat gives user to start VM allocation activity.

6. Submit - This module submit the application created by the user and VM is allocated according to the parameters .

   After the final step of the application , a text file will be generated that appends the meta data each time the application is processed. The fields in the text contains the following fields:

Job Type	Job Size	CPU	Memory	VCPU	Execution Time

   This data serves as the deciding factor for cloud environment every time an application will be executed so the optimum resources are utilized based on the existing

results. The ontology algorithm will use this data as input and will provide optimum results that will preserve resources and enhance performance.

Chapter 4

Application Designing Interface

4.0.4 Application Designing Interface

The designing interface provides drag and drop facility to a user by which a new application can be developed according to the need of user using the pre defined components. Also an existing application can also be used by the user. The framework also serves as interface to see the results of the algorithm. Cloud detection is an important task in meteorological application. Cloud information is especially important for now-casting purposes1 and as an input for different satellite based estimation of atmospheric and surface parameters2-4. The solar energy is the principal source of energy in the solar system. The importance of capacity and utilizing it for various purposes is realized by human being. In order to measure the correct amount of solar energy reaching earth, the layers of cloud should be separated while estimating the solar energy of a particular area. Clouds have high reflectance and absorption property which is used to distinguish them with land, water or sea area. There is critical demand to develop application, which can calculate the presence of cloud by using the available satellite image processing data, so that prediction of radiated solar energy can be optimised and energy budget can be predicted more easily. Using MATLAB for satellite image processing, an application is developed to efficiently and effectively calculate presence of cloud

4.0.5 Approach used

The dataset contains mask of weather condition related to cloud . In order to provide a friendly interaction, a GUI has been created using MATLAB GUI Development Environment (GUIDE). MATLAB contains worker as their computational unit. Workers are

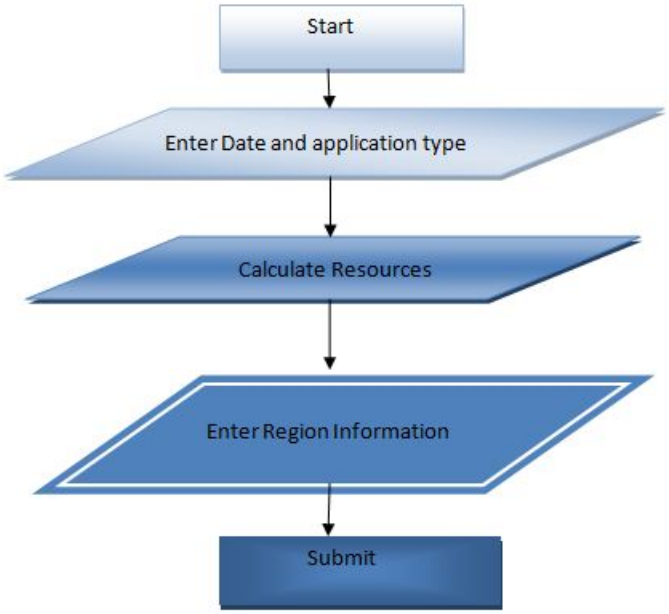

Figure 4.1: Flow of application

equivalent to number of cores, each worker has their own computational space and they can communicate with each other. Collection of worker is called pool. Matlab provides commands to open or close pool.

4.0.6 Flow of application

4.0.7 GUI

Parallel application can be executed in interactive or batch mode. MATLAB provides easy and efficient way to for compute image processing task involved in satellite image processing. Several other toolboxes are GUIDE (GUI Development Environment) that allows a user to create GUI using drag and drop facility and background function . The GUI is shown in 4.2

In the Fig. 4.2 , Main GUI is shown, which provides user several options. The Flow of operation is as follow. that will be used for calculation as shown in Fig. 4.3

- The user will start with entering the details, such as Mode of execution serial or parallel, also parameters that can be used to allocate the resources. The parameters are number of days and type of application. So user will enter both the details. and

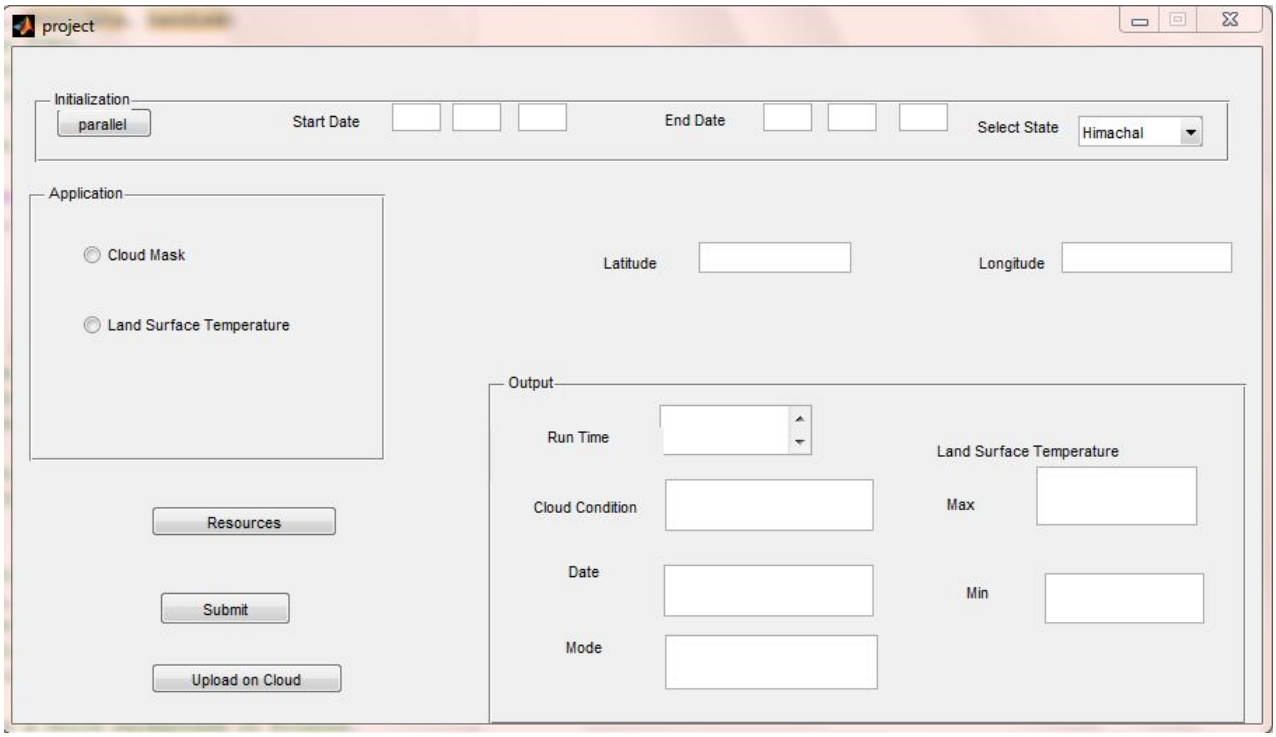

Figure 4.2: GUI of Application

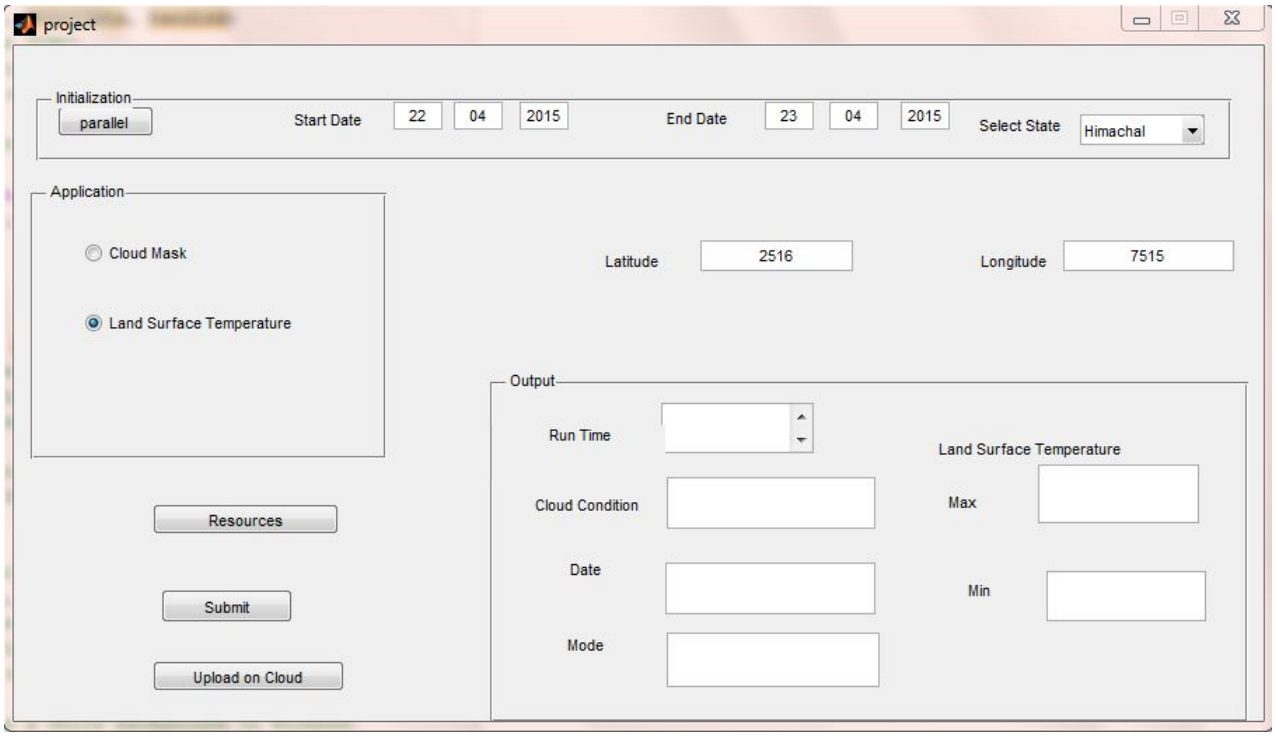

Figure 4.3: Details By User for resources

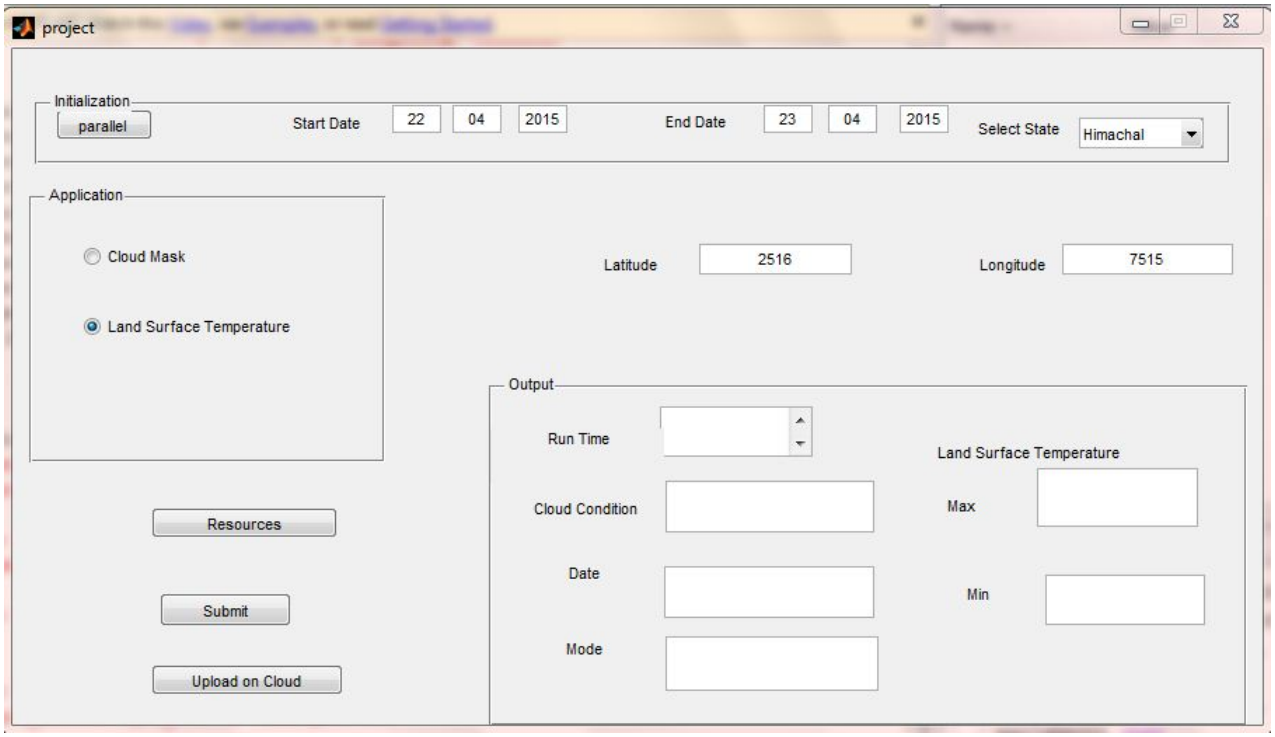

Figure 4.4: Uploading on website I

click on resources button to calculate the amount of data

- After estimating the resources ,User has to click Upload on cloud button to pass the resources to the cloud. This will direct to a website that accepts the parameters for ontology so as to decide the VM allocation. The website is shown in Fig. 4.5.

- After that user has to upload the application on cloud and reenter the details including the region , latitude and longitude information and press submit button . The application will distribute the computation according to the VM allocated. And the results will appear on the screen after the execution as shown in Fig. 4.6.

Output is displayed on the screen as well as it is stored in a text file. This gives user freedom to use recalculated results to carry on further calculation for prediction of data.

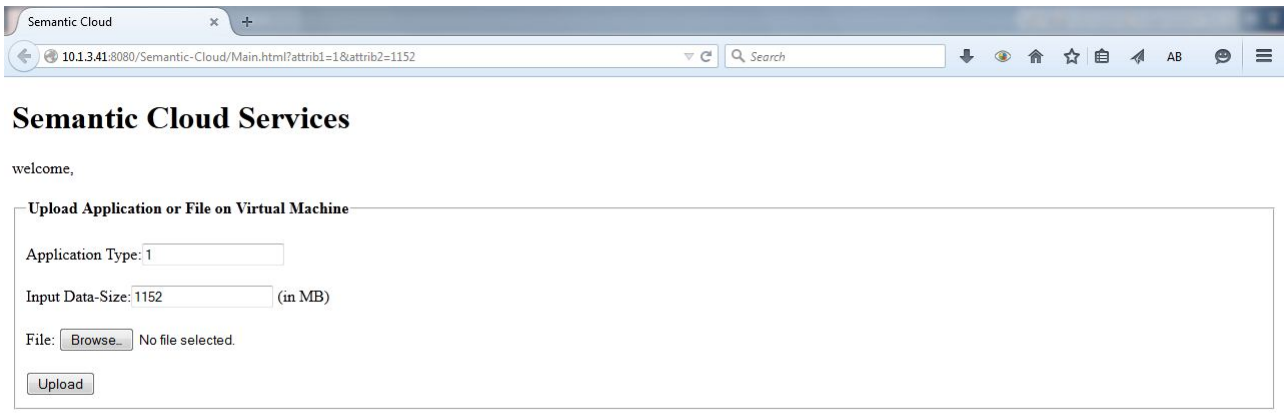

Figure 4.5: Semantic Cloud Services

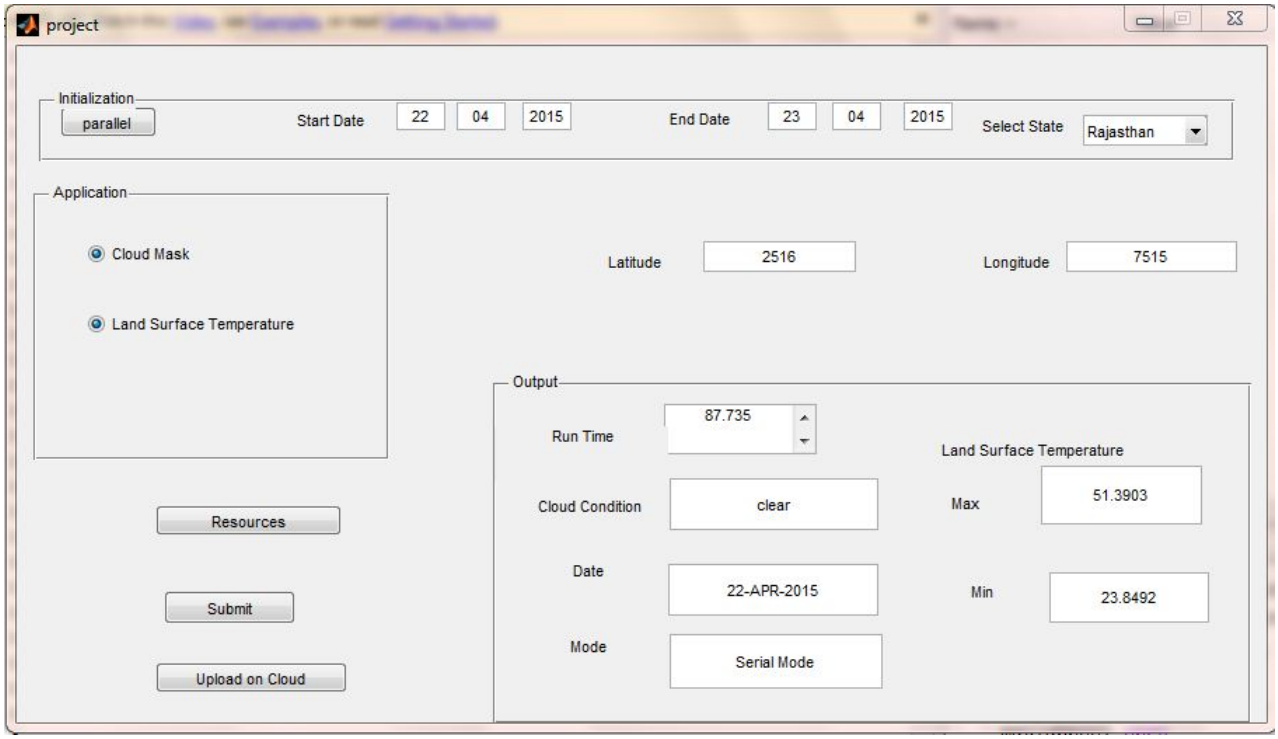

Figure 4.6: Output of application.

Chapter 5

Implementation

5.1 Results

5.1.1 Serial and Parallel approach

This application uses semantic approach to allocate and use resources. This is a need of toady's scenario because having too many resources can also results in resources wastage. This can be shown in Table 5.1, where same duration of data is computed with different resources. It can be inferred from the table that for Serial execution, it takes lot of time but for parallel execution, Multithreading environment gives results according to size of application and the computation involves in it. The Table 5.1 shows execution time for

Duration	1 Core	2 Core	3 Core	4 Core
0.5	0.9688	0.3125	0.09375	0.14063
2	1.2969	0.29688	0.3125	0.39063
4	2.4844	0.625	0.48438	0.65625
6	3.7818	0.7663	0.90625	1.1719
8	4.8906	0.875	0.96875	1.3554
10	6.1719	1.2969	1.25	1.6563
12	7.3438	1.625	1.5313	1.7344
14	8.6563	1.7813	1.5625	1.9219
16	9.8594	2.0781	2.3281	2.3688
18	11.125	2.375	2.7188	2.469
20	12.2656	2.4844	3	2.5438
22	13.7813	2.525	3.5109	2.6631
24	14.1296	2.612	3.7251	2.8554

Table 5.1: Table Showing execution time in different number of cores [17]

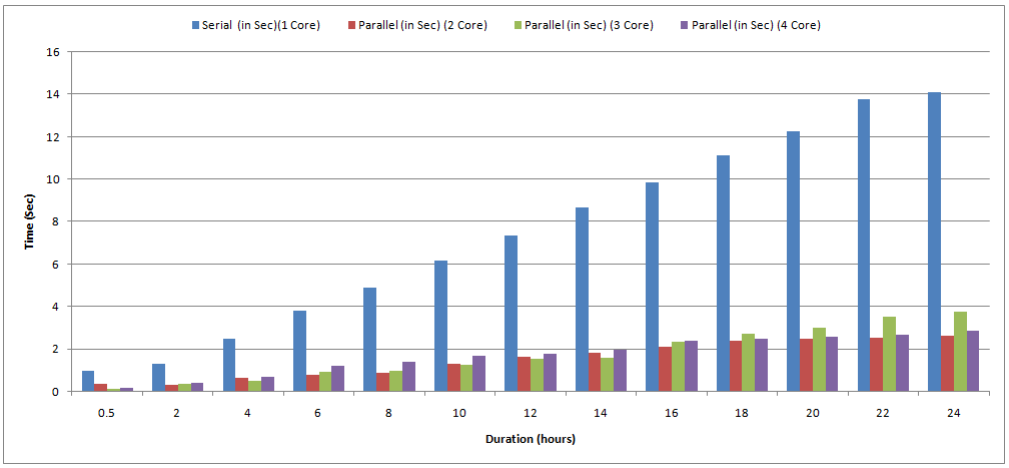

Figure 5.1: Execution Time in different Cores.

several duration of hours in different cores. Also this is represented graphically in Figure 5.1

Chapter 6

Conclusion and Future Scope

6.1 Conclusion and Future Scope

By this application, a common interface is build that provides various tools of meteorological prediction . Ontology provides a way to ascertaining the mapping relations between ontology which had been consequently made from the information bases.The application is build and it will be further modified to implement parallel processing in image processing so that it can run on multiple core.Following that an ontology algorithm has been build and the application is deployed onto cloud which uses the resources calculated by the application.

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