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Work-flux optimization for the use of GRASP algorithm in quasi-real-time

Master Thesis
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by

Mireia López Barrón

In partial fulfillment
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Revision history and approval record

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Abstract

Every copy of the thesis must have an abstract. An abstract must provide a concise summary of the thesis. In style, the abstract should be a miniature version of the thesis: short introduction, a summary of the results, conclusions or main arguments presented in the thesis. The abstract may not exceed 150 words for a Degree's thesis.

1 Introduction

An Introduction that clearly states the rationale of the thesis that includes:

1. Statement of purpose (objectives).
2. Requirements and specifications.
3. Methods and procedures, citing if this work is a continuation of another project or it uses applications, algorithms, software or hardware previously developed by other authors.
4. Work plan with tasks, milestones and a Gantt diagram.
5. Description of the deviations from the initial plan and incidences that may have occurred.

The minimum chapters that this thesis document should have are described below, nevertheless they can have different names and more chapters can be added.

1.1 Gantt Diagram

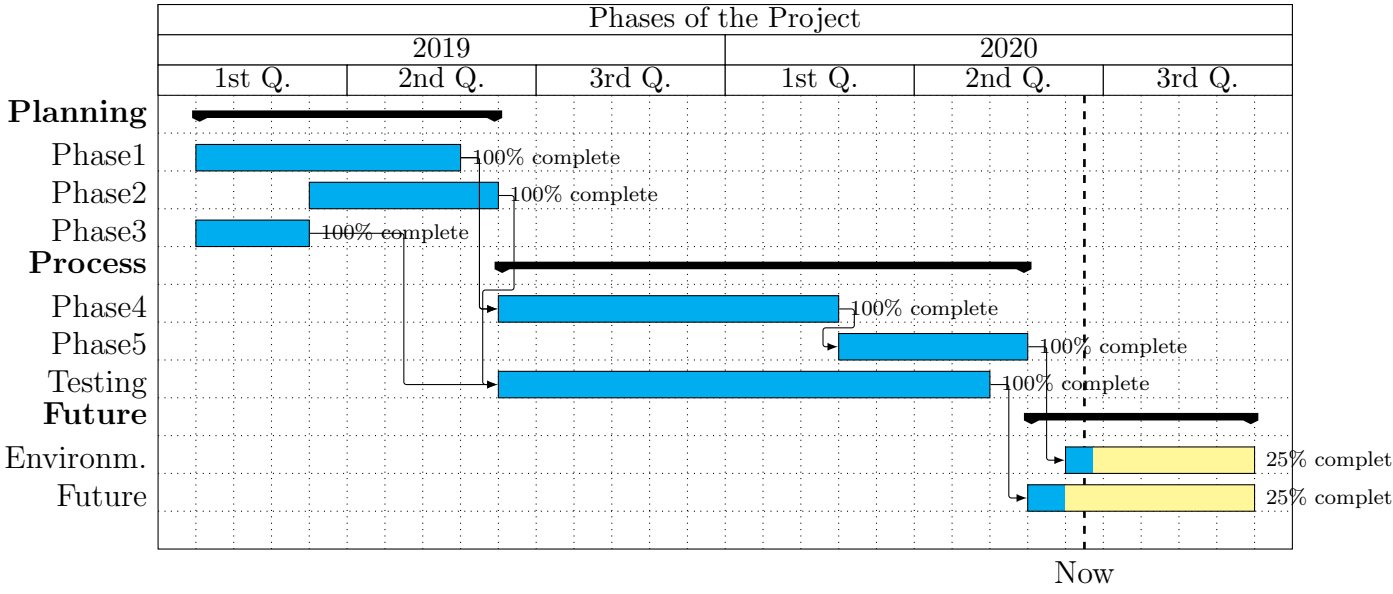

Figure 1: Gantt diagram of the project

For more information read the manual [1] of Skala.

1.2 Topic

2 State of the art of the technology used or applied in this thesis:

A background, comprehensive review of the literature is required. This is known as the Review of Literature and should include relevant, recent research that has been done on the subject matter.

2.1 Topic

Here you have a couple of references about LaTeX [3] and electrodynamics [2].

2.2 Topic

3 Methodology

In order to create a new application , it is necessary to follow the following steps, to create a strong foundation.

- Create a list of requirements
- Research and plan
- Design the architecture
- Design the graphical user interface (GUI)
- Set up development environment
- Implement
- Test
- Deployment
- Maintenance

For the development of the application, it has been decided to use an hybrid structure, using Object Oriented Programming (OOP) with C# and MATLAB scripting.

The main advantages of using C# with OOP are that it allows the code to be reusable, organized and easy to maintain [7]. In this project, it has been used for the development of the Graphical User Interface and the controllers for both, web services and MATLAB script management.

In the other hand, MATLAB provides a specialized environment for numerical calculations, simulations, and complex data analysis[8]. Working directly with matrixes and arrays makes the data processing and visualitzation easier and more efficient.

4 List of requirements

This first step is crucial for the correct result. It is needed to define a clear and well defined list of requirements. This defines the main scope of the project, the different futures to be implemented and prevents from building something that is not desired. This project, need to be able to fulfill the following requirements:

1. Application can be executed in CALCULA operating system (Linux)
2. Download measurements from the internet
   (a) Download measurements from a defined date range
   (b) Download measurements from a defined location
   (c) Download measurements from the Actris-Earlinet Data Portal [5]
      - Download ELPP products
      - Download Optical products
   (d) Download measurements from the Aeronet web [6]
      - Download Raw Almucantar Sky Scan Radiance measurements
      - Download Raw Hybrid Sky Scan Radiance measurements
      - Download Raw Principal Plane Sky Scan Radiance measurements
      - Download Raw Polarized Principal Plane Sky Scan Radiance and Degree of Polarization measurements
      - Download Raw Polarized Almucantar Sky Scan Radiance and Degree of Polarization measurements
      - Download Raw Polarized Hybrid Sky Scan Radiance and Degree of Polarization measurements
   (e)
3. Filter Earlinet measurement files depending on the the data type
   (a) 002, 008
   (b) 007
4. Execute full GRASP algorithm sequence:
   (a) Preprocessing:
      -
      -
      -
      -

-
    (b) Retrieve aerosol optical depth
    (c) Retrieve aerosol extinction
    (d) Retrieve aerosol single scattering albedo
    (e) Retrieve aerosol Ångström exponent
5. Execute the GRASP algorithm
6. Give the user the possibility to plot the different results after executing the algorithm
7. Application can work with project/workspaces
    (a) User can create, open and import a project
    (b) Downloaded data from web services are stored in the project folder
    (c) Results of the GRASP algorithm are stored in the project folder
    (d) Once a project is closed, all the data is deleted
8.
9.

5 Research and plan

This step helps optimize both time and resources by preventing unnecessary work. Since this project builds upon a previous one, it is not required to develop new code for certain application requirements, but to adapt it to the new needs. Furthermore, the availability of APIs for downloading measurements from the ACTRIS–EARLINET Data Portal [5] and AERONET web application [6] provides a convenient and efficient solution that can significantly reduce development effort.

5.1 Web services development

5.1.1 ACTRIS–EARLINET service

The ACTRIS–EARLINET Data Portal provides a REST API for downloading measurements [9]. This web, shows all the different requests that are supported by the API, gives examples of how to use them and the expected response.

Having all this information available is really helpful, since it allows to localize the requests that are needed for the project requirements.

After testing and comparing the different options and the obtained responses, it becomes clear that the best option is to use the "/products/downloads" endpoint, which allows to download the measurements in a compressed format, filtering the data by type, date and station name.

Even if other configuration parameters are available (measurementID, wavelength and opticaltype), it is not necessary to use them for the project requirements.

Once the behaviour is understood, a class is created to handle the requests and responses of the API.

```
1  public class EarlinetService{
2      string baseUrl = "https://api.actris-ares.eu/api/services/restapi/";
3      public virtual System.Threading.Tasks.Task<bool>
           DownloadProductByDateRangeAsync(string type,string FromDate,
           string ToDate,string outputFolder){
4          return DownloadProductByDateRangeAsync(type,FromDate,ToDate,
               outputFolder,System.Threading.CancellationToken.None);
5      }
6
7      public async Task<bool> DownloadProductByDateRangeAsync(string type,
           string FromDate,string ToDate,string outputFilePath,System.
           Threading.CancellationToken cancellationToken = default){
8          try{
9              string url = $"{baseUrl}products/downloads?kind={type}&
                   fromDate={FromDate}&toDate={ToDate}&stations=brc";
10             using (HttpClient client = new HttpClient()){
11                 HttpResponseMessage response = await client.GetAsync(url
                       );
12                 response.EnsureSuccessStatusCode();
13                 using (var fs = new FileStream(outputFilePath,FileMode.
                       Create,FileAccess.Write,FileShare.None)){
```

```
14                      await response.Content.CopyToAsync(fs);
15                  }
16                  System.IO.FileInfo f = new FileInfo(outputFilePath);
17                  if (f.Length <= 1048)
18                      return false;
19                  return true;
20              }
21          }
22          catch (Exception ex){
23              return false;
24          }
25      }
26  }
```

For the creation of this class it has been taken into account the fact that the DownlaodProductByDateRangeAsync method can be used in different points of the program with different configurations.It has also been implemented in such a way that adding new functionalities is easy using the same design pattern.

5.1.2 AERONET service

The AERONET web does not provide a REST API portlet, but it includes web servicie documentation that helps the implementation of a costume service.

The amount of files to be downloaded in this website is larger thant the one in Earlinet, and its documentation can be found in three different sections of the web:

1. Optical Depth[10]:
   - Aerosol Optical Depth (AOD): (descripcion de los datos), with extension .lev15
   - Spectral Deconvolution Algorithm (SDA) data: (descripcion de los datos), with extension .ONEILL_lev15
2. Aerosol Inversions[12]:
   - Inversion products:(descripcion de los datos), with extension .all
3. Raw Products Optical Depth[11];
   - Raw Almucantar: (descripcion de los datos), with extension .alm
   - Raw Polarized Almucantar: (descripcion de los datos), with extension .alp

For the creation of this class it has been taken into account the fact that the DownlaodProductByDateRangeAsync method can be used in different points of the program with different configurations.It has also been implemented in such a way that adding new functionalities is easy using the same design pattern. For clarity and organization, it has been created the DataType Enum, since the different data types need different Url content in order to be downloaded.

```
public class AeronetService{
    private string baseUrl = "https://aeronet.gsfc.nasa.gov/cgi-bin/";
    public async Task DownloadDataAsync(string destinationFile,string
        url){
        try{
            using (HttpClient client = new HttpClient()){
                var response = await client.GetAsync(url);
                response.EnsureSuccessStatusCode();

                var content = await response.Content.
                    ReadAsByteArrayAsync();
                await File.WriteAllBytesAsync(destinationFile,content);
            }
        }
        catch (Exception ex){
            Console.WriteLine($"Error downloading data: {ex.Message}");
        }
    }

    public string BuildUrl(DataType _dataType,DateTime startDate,
        DateTime endDate,string productType = "",string site = "",string
        product = "",string AVG = "",bool isEnabled = false){
        switch (_dataType){
            case DataType.AerosolInversions:
                if (isEnabled)
                    return BuildUrlAerosolInversions(startDate,endDate,
                        productType,site,product,AVG);
                else
                    return BuildUrlAerosolInversions(startDate,endDate);

            case DataType.OpticalDepth:
                if (isEnabled)
                    return BuildUrlOpticalDepth(startDate,endDate,
                        productType,site,AVG);
                else
                    return BuildUrlOpticalDepth(startDate,endDate,
                        productType);

            case DataType.RawProductsOpticalDepth:
                if (isEnabled)
                    return BuildUrlRawProductsOpticalDepth(startDate,
                        endDate,productType,site,AVG);
                else
                    return BuildUrlRawProductsOpticalDepth(startDate,
                        endDate,productType);
        }
        return "";
    }

    {...} //BuildUrl methods can be found in GitHub repository
}
```

In this application, this class is only used to download the data files listed above, but

other types could be downloaded by calling only the DownloadDataAsync and BuildUrl methods in a line.

5.2 Matlab controller development

As it was mentioned in the introduction, this project is a second attempt to offer a solution of the same problem.

While the first application proposed a complete implementation in MATLAB, the current approach differs. However, since many requirements are shared between both, the previously developed code has been adapted to the new hybrid system in order to be executed with C#. In order to do that, different actions have been taken.

5.2.1 Create script configuration files and output files

Since the project is hybrid, it is necessary to create a configuration file for the script that will be executed in C#. This file will contain the parameters needed to execute the script. In the previous approach, this files were not needed, since GUI introduced parameters were being stores in the MATLAB workspace. The use of these files, allow the communication between the two different languages. Configuration files allow the different scripts to obtain the information and parameters that the user introduced, while the output files allow the application to know the corresponding results and notify the user about it.

5.2.2 Automatize MATLAB repository for needed data files

In the older version, it was needed to manually download the data files from the different websites and at the respective files in two concretes repositories. Files downloaded from Aeronet site were located in a folder inside the Matlab Project called /repository/AERONET/. Files downloaded from Earlinet site were located in a folder inside the Matlab Project called /repository/LIDAR/ and inside this folder, a folder for each measurementID was created containing all the data files corresponding to that measure. In order to automatize this process, a script has been created that downloads the data files from the AERONET website and stores them in a local repository.

In order to be able to automatize the process of downloading and giving the application the capacity of work with different workspaces, the repository location has been modified and automatized inside the application. The corresponding file is saved as configuration parameter in both, application and script.

5.2.3 Adapt old scripts to new file formats

5.2.4 Execute MATLAB scripts from C#

In order to execute the MATLAB scripts from C#, it is needed to create a method that uses the ProcessStartInfo class, that can be imported as a library, to execute the MATLAB script. The following example shows a method called RunMatlabScript that takes a string parameter containing the path to the script to be executed. The method uses the Process class to execute the script and it redirects the standard output and standard

error to the console.

```
public static void RunMatlabScript (string scriptPath){
    try{
        ProcessStartInfo startInfo = new ProcessStartInfo{
            FileName = "matlab",
            Arguments = $"-batch␣\"run('{scriptPath}')\"",
            RedirectStandardOutput = true,
            RedirectStandardError = true,
            UseShellExecute = false,
            CreateNoWindow = true
        };
        using var process = new Process { StartInfo = startInfo };
        process.OutputDataReceived += (s,e) =>{
            if (e.Data != null)
                Messenger.Default.Send<string>("WriteMatlabOutput",e.
                    Data);
        };
        process.ErrorDataReceived += (s,e) =>{
            if (e.Data != null)
                Messenger.Default.Send<string>("WriteMatlabErrors",e.
                    Data);
        };
        process.Start();
        process.BeginOutputReadLine();
        process.BeginErrorReadLine();
        process.WaitForExit();
        if (process.ExitCode == 0){ //OK
            Logger.Log($"Script␣was␣executed␣correctly,executing␣post␣
                execution␣actions␣.␣.␣.");
            script.PostExecutionActions();
        }
        else{
            Logger.Log($"Error␣occured␣during␣execution,executing␣post␣
                execution␣actions␣.␣.␣.");
            script.PostExecutionActions(false);
        }
    }
    catch (Exception ex){
        Logger.Log($"Error␣occured␣during␣execution,executing␣post␣
            execution␣actions␣.␣.␣.");
        script.PostExecutionActions(false);
    }
}
```

6 Architecture

6.1 Tools

- MVVM
- SOLID principles

6.2 Project architecture

7 Graphic User Interface (GUI) design

8 Implementation

8.1 Set up development enviroment

9 Testing

10 Results

This should include your data analysis and findings

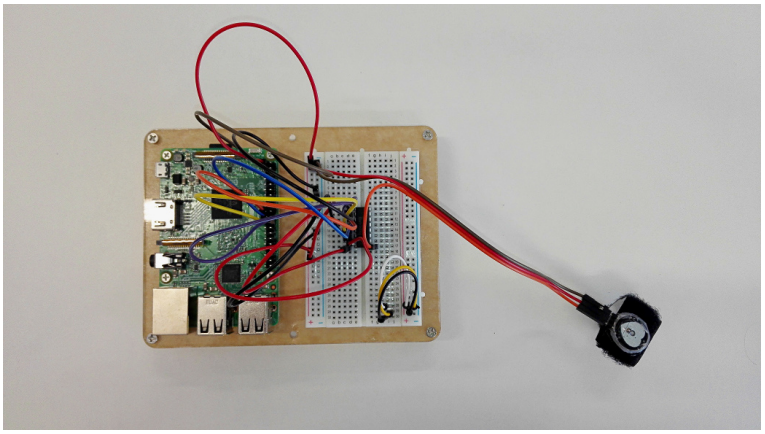

Figure 2: Prototype setup.

Table 1: This is the other caption. Since the trial size of the experiments showed is one second, the number of *Target* and *Impostor* data corresponds to number of trials or seconds

Dataset	**Label**	**Train**	**Validation**	**Develop**	**Test**
First	Target	135	45	30	30
	Impostor	5,220	1,740	1,890	2,880
	#Subjects		31		12
Second	Target	144	80	48	48
	Impostor	2,014	1,119	1,343	1,545
	#Subjects		15		5

Algorithm 1 Temperature-Distributed algorithm

procedure TEMP-SPREAD($GN_i, HN_j, temperatures$) ▷ Lowest temperature priority
  $temperature\_list \leftarrow short(temperatures)$
  $max_temperature \leftarrow max(temperature_list)$
  $ThresHold \leftarrow 0.5$
  $temperature\_impact \leftarrow 0.2$
  for GN_i in $i = 1, 8$ **do** ▷ Iterate every hardware node on the given GN
    $it\_temperature \leftarrow temperature\_list(GN_i)$
    $temp\_weight \leftarrow \frac{max\_temperature - it\_temperature}{max\_temperature} * temperature\_impact$
    $\omega(Master - GN_i) \leftarrow ThresHold * temp\_weight$
    for HN_j in $j = 1, n$ **do**
      if $available\_accel_{i,j} > busy\_accel_{i,j}$ **then**
        $policy_\omega = \frac{AvailableHW}{TotalHW} * ThresHold$
        $\omega(GN_i - HN_{i,j}) \leftarrow ThresHold + policy_\omega$
      else
        $\omega(GN_i - HN_{i,j}) \leftarrow 1$
  $node \leftarrow find\_djistra\_shortest\_path(Master\_Node, aux\_node)$
  $returnnode\ b$ ▷ The gcd is b

11 Conclusions

References

[1] Wolfgang Skala. Drawing gantt charts in latex with tikz.

[2] Albert Einstein. Zur Elektrodynamik bewegter Körper. (German) [On the electrodynamics of moving bodies]. *Annalen der Physik*, 322(10):891–921, 1905.

[3] Michel Goossens, Frank Mittelbach, and Alexander Samarin. *The LaTeX Companion*. Addison-Wesley, Reading, Massachusetts, 1993.

[4] Donald Knuth. Knuth: Computers and typesetting.

[5] C.N.R. IMAA. Actris-earlinet data portal. Web Application available at `https://data.earlinet.org/earlinet/desktop.zul`, 2024.

[6] NASA. Aerosol robotic network (aeronet). Web Application available at `https://data.earlinet.org/earlinet/desktop.zul`, 2025.

[7] Miriam Martínez Canelo. ¿qué es la programación orientada a objetos? Web Application available at `https://profile.es/blog/que-es-la-programacion-orientada-a-objetos/`, 2025.

[8] MathWorks. Matlab. Web Application available at `https://es.mathworks.com/products/matlab.html`, 2025.

[9] C.N.R. IMAA. Actris-earlinet rest api. Web Application available at `https://data.earlinet.org/api/swagger-ui/`, 2025.

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[11] NASA. Raw products aerosol optical depth. Web Application available at `https://aeronet.gsfc.nasa.gov/print_web_data_help_v3_raw_sky_new.html`, 2025.

[12] NASA. Aerosol inversions. Web Application available at `https://aeronet.gsfc.nasa.gov/print_web_data_help_v3_inv_new.html`, 2025.

Appendices

Appendices may be included in your thesis but it is not a requirement.