TFG: Sat2Dron 3: Spectral Superresolution
Initial report

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1 Proposed project

Multispectral (MS) remote sensing sensors are proven to acquire useful information in order to perform object detection, classification and other applications. These sensors acquire information within limited broad spectral bands, usually between 3 and 10 number of bands. This low number of bands become a drawback when performing more detailed analysis of earth's surface. Hyperspectral (HS) sensors are instruments designed to have a considerably greater number of narrow spectral bands compared to MS sensors. Hence, this type of sensor becomes the best option for distinguishing spectral resembling material of the earth's surface. However, availability of immediate HS data is currently lacking.

Most of the work involving superresolution has been in the spatial and temporal modalities in which Deep Learning has achieved state-of-the-art results[1]. Nevertheless, little study has been involved with increasing the spectral information of an image with Deep Learning.[2]

Daniel Rojas' TFG proposes transforming multispectral data to hyperspectral data using Deep Learning techniques in order to increase the spectral information from the MS data by more than 10 times –from less than 10 number of bands to over a 100 bands–.

2 Main objectives

1. Increase the number of spectral bands in multispectral data by a factor of 2.
2. Increase the number of spectral bands in multispectral data by a factor of 10.
3. Achieve domain adaptation and transfer the learning to other satellites using zero-shot learning techniques.

4. Generate architectures that are innovative and competitive in a research area that does not have a large quantity of literature or resources.
5. Evaluate our model comparing the results obtained with current architectures.

3 Side objectives

1. Propose a novel architecture that achieves state-of-the-art performance.
2. Combine all the modalities of superresolution (spatial, temporal and spectral) into one architecture.

4 Learning outcomes

1. Master deep learning techniques applied to computer vision.
2. Master the manipulation and processing of satellite remote sensing imagery.
3. Learn the state-of-the-art of superresolution and deep learning in different modalities and be able to use the knowledge to propose novel architectures.
4. Learn by performing a large quantity of computational experiments.
5. Be introduced to the research field.
6. Describe the overall conclusions from all the experiments performed into an article document format.
7. Decompose a big challenge into different tasks and milestones.
8. Be challenged with a project in which there is little literature.

5 Methodology

The management of a project is of a great degree of importance to meet the final objectives and deliver them on time. In order to choose the best alternative available, these next points have been taken into consideration:

- Individual project: the work of the project is realized by a single person. Therefore, there is no need of daily communication and coordination with colleagues, neither of a strict schedule.
- Weekly meetings with supervisor: the student and his supervisor have agreed to hold weekly meetings to show the progress and consult any doubts. This gives the student the aim to set weekly minor goals and work from the start of the project.

- Poor literature in the area: the research topic has not been deeply studied by other researchers using the techniques that the student is planning to utilize. Thus, there is a level of uncertainty on the overall project, which makes the timelines not as clear.
- Novelty: although computer vision and deep learning have already been introduced to the student, remote sensing and the satellite scene is new for him, as well as other tools that will be used. Therefore, the mastering of these tools will be required in order to achieve the goals and it could affect the timelines.

The chosen methodology to manage the student's time is Kanban due to the fact that it is a methodology characterized for improving the speed and quality of work. It will make the student finish the current work-in-progress set as multi-tasking is limited. Moreover, it enables a visible display of the project and work in progress which will be of a great use when communicating with the supervisor. Finally, weekly minor goals will be set in order to increase the motivation and performance of the student.

6 Work plan

1. Documentation (Weeks: 1-2): study the literature, actual and old, of superresolution and deep learning. We will emphasize on the work related to our field and desired satellites, but we will also explore other alternatives. Moreover, the study of the different characteristics of satellites and their instruments will also be realized. This phase is emphasized in the initial part of the project but will remain active throughout the whole project due to its importance and need.
2. Introduction of new tools (Weeks: 2-5): learning to use new tools such as GDAL, QGIS, Earth Engine, among others, and the downloading and processing of satellite imagery. This phase will be the base to get my further work done.
3. Reproduction of state-of-the-art (Weeks: 3-7): in order to achieve a good understanding of the matter and increase the familiarity with the new tools and methods, a reproduction of the state-of-the-art scene[2] (no code available) will be produced. This phase overlaps with the previous phase due to the fact that this phase is a way of improving the skills needed and achieve a solid learning on the matter.
4. Proposing a novel architecture (Weeks: 7-13): more study and computational experiments will be done in order to achieve a novel architecture that stands out from others. This phase is the most exploratory one, it will be based on research among different areas, learning what can be done in order to improve a solution and thinking outside the box. Getting a very broad knowledge, design architectures based on the characteristics

that will get the most out of it and performing trial-and-error will be the objectives of this phase. The timeline for this phase starts from when the student gets a good practical understanding on the problem and it ends soon enough to be able to propose new approaches, such as the zero-shot learning.

5. Zero-shot learning approach (Weeks: 13-17): the last main goal of the project is that the learning of the network can be applied to other satellites and instruments different than the one used for training. Using very little or none set of data, we hope to achieve satisfactory results. This phase remains as the last technical phase, the project could diverge to some different specific goal if we find a viable solution to an unsolved problem.

6. Elaborating a final report (Weeks: 18-22): a final article report will be written up explaining our approach and solution to the problem, specifying the processing of data, the design of the architecture, decisions taken, etc.

References

[1] et al. Lei Zhang. Deep blind hyperspectral image super-resolution. *IEEE TNNLS*, 2020.

[2] Subir Paul and D. Nagesh Kumar. Transformation of multispectral data to quasi hyperspectral data using convolutional neural network regression. *IEEE TGRS*, 2020.