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Semantic orchestration of image processing services for environmental analysis

Élisabeth Ranisavljević [a,*], Florent Devin [a], Dominique Laffly [b], Yannick Le Nir [a]

[a] École Internationale des Sciences du Traitement de l'Information, 2 boulevard Lucien Favre, CS 77563, 64 075 PAU CEDEX, France
[b] University of Toulouse, GEODE UMR 5602 CNRS, Maison de la recherche, 5 allées Antonio Machado, 31 058 TOULOUSE CEDEX, France

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ABSTRACT

In order to analyze environmental dynamics, a major process is the classification of the different phenomena of the site (e.g. ice and snow for a glacier). When using *in situ* pictures, this classification requires data pre-processing. Not all the pictures need the same sequence of processes depending on the disturbances. Until now, these sequences have been done manually, which restricts the processing of large amount of data.

In this paper, we present how to realize a semantic orchestration to automate the sequencing for the analysis. It combines two advantages: solving the problem of the amount of processing, and diversifying the possibilities in the data processing. We define a BPEL description to express the sequences. This BPEL uses some web services to run the data processing. Each web service is semantically annotated using an ontology of image processing. The dynamic modification of the BPEL is done using SPARQL queries on these annotated web services.

The results obtained by a prototype implementing this method validate the construction of the different workflows that can be applied to a large number of pictures.

1. Introduction

1.1. Context

Analyzing landscapes, its dynamics and environmental evolutions require regular data from the sites. In the following, we will use as an example the analysis of the East Loven glacier mass balance in Spitsbergen (78°N, 12°E, Svalbard, Norway). Several readings must be done at different levels (Bernard, 2011). One level would be in the field, for example reading temperature, snow density and water flow. The other level would be a distance reading, like getting a global view of the glacier (snow/ice blanket) and its evolution with remote sensing control. The environmental analysis is obtained by linking all these pieces of information together (temperature, water balance, classification of the different glacier states, etc.).

Ideally, satellite images should be used for the classification. Nevertheless, these images are not always workable due to poor weather conditions (including common heavy cloud cover at polar latitudes). Moreover, they are not always affordable. Besides, fast events like floods or blankets of snow are missed by satellite based studies, since the slowest sampling rate is unable to observe them (Bernard, 2011). In order to complement satellite imagery (FORMOSAT), a set of ground based autonomous automated digital cameras have been installed in the glacier, as part of the scientific program *Hydro Sensor Flow* supervised by Corripio (2004), Hinkler et al. (2002), Laffly et al. (2012), Newbery and Southwell (2009). The instruments were placed on the ridges surrounding the East Loven basin in order to cover most of the glacier basin with the different view angles. "Each instrument is based on a COTS (commercial off-the-shelf) digital camera (either Leica D-Lux4 or Panasonic Lumix LX3 – the latter being packaged in a stronger aluminum case is more difficult to modify), selected for its lens optics quality, high sensor resolution (10 Mpixel sensors), and data storage on Secure Digital (SD) mass storage memory card. Indeed, such a mass storage provides both the bandwidth needed to keep the camera powered for as short a duration as possible (in order to reduce global power consumption) while requiring few enough signals for the card holder to be located away from the camera itself, accessible to the user while keeping the camera in an air tight enclosure." – (Laffly et al., 2012). An example of such a concept is given in Fig. 1. The cameras have been programmed to take 3 pictures a day (08:00, 12:00 and 16:00) in order to follow the

* Corresponding author.
E-mail addresses: erc@eisti.eu (É. Ranisavljević), fd@eisti.eu (F. Devin), dominique.laffly@gmail.com (D. Laffly), yl@eisti.eu (Y. Le Nir).
URL: http://www.eisti.fr (É. Ranisavljević).

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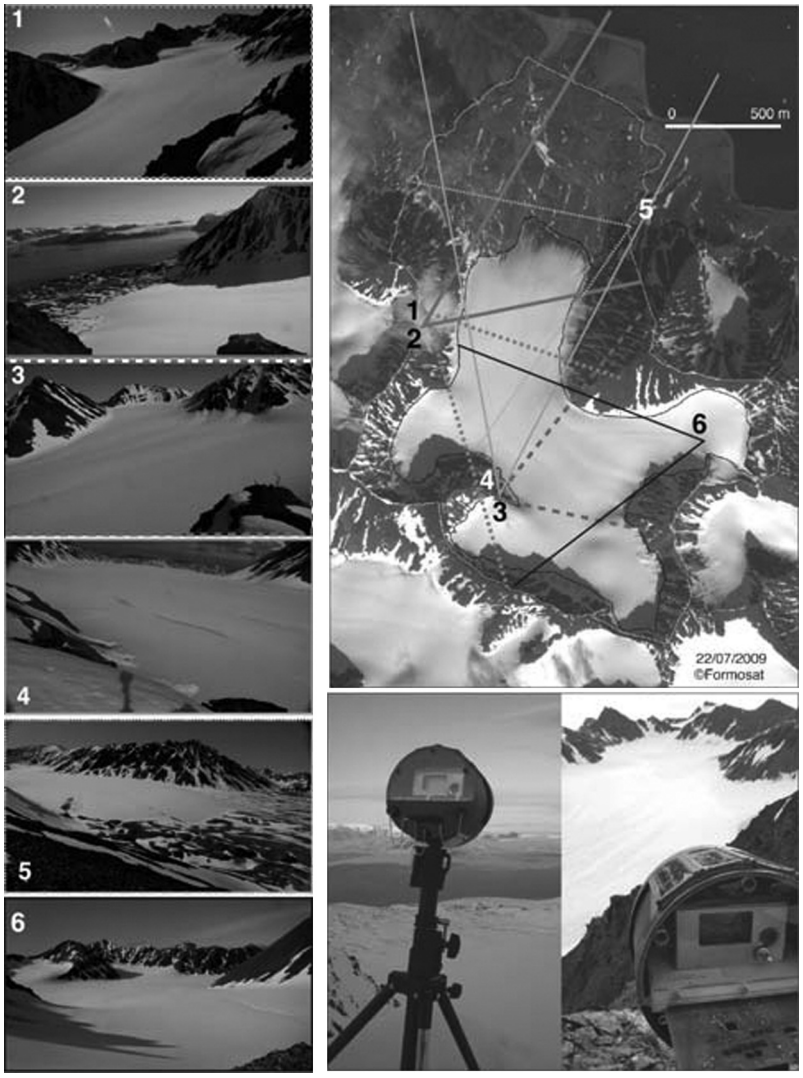

Fig. 1. Ground based autonomous automated digital cameras for daily reading (Laffly et al., 2012). Left: the *in situ* pictures. Top right: position of the cameras and their view angle on the satellite image. Bottom right: experimental setup, in which a digital camera is packaged in a waterproof, air tight enclosure.

spatio-temporal evolution of the glacier regularly. Taking more pictures should provide useful information, but it fills quicker the memory card. This implies to collect the data more often. Taking less pictures reduces the probability to detect fast events. These pictures form a huge database, but are disturbed by:

- weather conditions: water drop, fog, ice on the pictures, etc.;
- electronic deficiency: more or less pictures taken a day;
- physical constraints on the camera: geometry variations on the pictures.

To use these pictures in spite of the disturbances, several tasks must be performed. The goal of all the tasks on the pictures is to create a mosaic to the photos as an alternative of the satellite images. The aim is also to classify the different phenomena, in order to analyze the evolution of the glacier phenomena (ice, snow, etc.). In order to get the same view, all the pictures have to go through several tasks.

1.2. Image processing

We can distinguish 2 types of tasks: the ones due to unpredictable constraints of the site (e.g. the weather condition) and the ones due to the transformation of the *in situ* pictures to an alternative of the satellite view.

Among the tasks due to unpredictable constraints of the site, we have: the usability and cleaning, the dating and the cropping of the pictures.

- `Usability and cleaning`: The tasks of usability of pictures detect the pictures which are too greatly disturbed by poor weather conditions like fog, snow or water on the lens. Some perturbations can be cleaned, but others make the pictures meaningless. The goal of this task is to clean the picture if possible and to remove the pictures which do not give any information about the glacier from the set of pictures.
- `Dating`: One of the reasons for maintenance operation is the discharge of the camera's internal battery. In order to take three pictures a day, a microcontroller has been programmed to capture 3 images a day. This microcontroller allows the camera 20 s to turn on, to focus, to take the picture and to save it on the memory card. Due to poor weather conditions, there are some situations where the microcontroller is ''asleep'' for several days. Moreover, if the camera does not succeed in taking the picture in the 20 s (e.g. if there is snow on the lens and the camera cannot focus), the picture is not taken. As the cameras are