Semantic-Based Grid Workflow for Video Processing

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Abstract: Automatic video processing for the EcoGrid poses many challenges as there is a vast amount of raw data that need to be analysed effectively and efficiently. Furthermore, ecological data are subject to environmental changes and are exception-prone, hence their qualities vary. We propose a hybrid workflow composition system that strives to provide automation to speed up this process. This approach utilises ontologies to provide semantic interoperability and Planning for task decomposition. We wish to extend the flexibility of workflow systems to vision problems which are highly specialised by nature. The solution sought is one that best satisfies the system's requirements and that overcomes the limitations of existing Grid workflow composition systems.

The Problem and Motivation

Continuous data collection within the EcoGrid [1] poses a great challenge as they will need to be transformed into usable information for the ecologists in a timely fashion. For instance, one minute of video clip typically takes 1829 frames and is stored in 3.72 Mbytes. That translates into 223.2 MB per minute, 5356.8MB per day and 1.86 Terabytes per year for one operational camera, and due to the unpredictability of nature, one may not easily skip frames as they may contain vital information. Based on our own experience, one minute's clip will on average cost 15 minutes' manual processing time. This means that one year's recording of a camera would cost human experts 15 years' effort just to perform basic analysing and classifying tasks. Currently there are three under water cameras in operation and this will cost a human expert 45 years just to do basic processing task. **This is clearly an impractical situation and more appropriate automation methods must be deployed.**

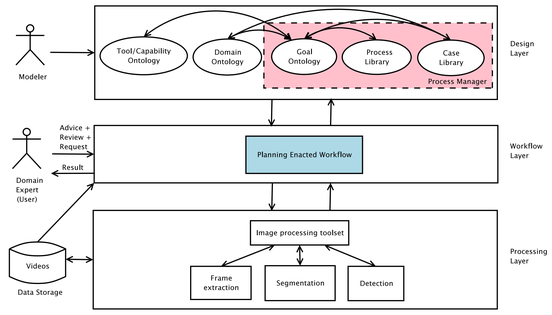
Sample images from EcoGrid video clips that need to be analysed!

The requirements for a suitable system are captured.

- Process Automation with Loop-Enabled
- Performance-Based Selection
- Adaptive, Flexible and Generic Architecture
- Semantic-Based Compatibility

To this end, most existing Grid workflow systems are composed **manually** which would require low-level expertise from the user. Thus the provision of automatic workflow composition within the Grid is challenging and requires more attention.

The Approach



Hybrid Workflow Composition Framework for Video Processing [2]

The central idea of this architecture is that users who do not possess image processing expertise can conduct complex video processing tasks within a dynamic environment. To enable Grid-compatibility, the components in the proposed framework could be wrapped as Grid services [3].

Design layer. Contains components that describe the goals, domain descriptions, capabilities and processes to be carried out in the system.

- Goal ontology contains the high-level goals and constraints that the user will communicate to the system.
- Domain ontology describes the concepts and relationships associated with the videos, such as the lighting conditions, colour information, position, orientation as well as spatial and temporal aspects.
- Capability ontology contains the classes of video and image processing tools and their functionalities.

The process library holds instances of executable processes to perform the tasks of the workflow while the case library keeps track of viable solutions and their performance levels so they can be reused if necessary.

Workflow layer. Acts as the main interface between the design and processing layers as well as the user. A *Planning- and ontology-enriched workflow enactor* acts as the interpreter of the events that occur within the system and plays the important role of choreographing the flow of processing within the system.

Processing layer. Consists of a set of video and image processing tools that will act on the data. Once a workflow has been established, these tools may work on the videos directly. The final result is passed back to the workflow layer for output and evaluation.

Present and Future Work

An initial development of the ontologies and a walkthrough for a detection example have been implemented manually [4].

Sample result (L-R): original, background and detected images [4]

Collaboration with image processing experts is on-going to perform various analyses on the EcoGrid videos using several vision libraries in order to obtain the process models and performance levels of the different tools used. The tasks include detection, segmentation, classification and object tracking. Thus the heuristics that vision experts use to solve video processing tasks could be obtained and incorporated in the system via the Planner. The workflow tool could be implemented by linking the ontologies to the Planner and interfacing with the other components.

References

[1] EcoGrid National Center for High Performance Computing, Taiwan, 2006. http://ecogrid.nchc.org.tw/.
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[3] G. Nadarajan, Y.-H. Chen-Burger, and J. Malone. Semantic Grid Services for Video Analysis. In *Web Intelligence and International Agent Technology Workshops*, Dec 2006. pp. 121–124.
[4] G. Nadarajan and A. Renouf. A Modular Approach for Automating Video Analysis. In *International Conference on Computer Analysis of Images and Patterns (CAIP'07)*, Aug 2007.