Cloud Computing for High Performance Image Analysis on a National Infrastructure

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Cloud computing services offer highly scalable and efficient solutions with a large pool of virtualized resources. They are becoming an increasingly prevalent service delivery model. We have developed a cloud-based image analysis toolbox to provide a wide user base with easy access to the software tools we have developed over the last decade. The toolbox is provided as a service on an Australian national cloud infrastructure [NeCTAR].

Architecture of Cloud-Based Image Analysis

Our cloud-base image analysis and processing toolbox comprises a collection of physical and virtualized resources connected through networks, including the NeCTAR research cloud Infrastructure as a Service (IaaS), cloud enabled image analysis and processing Platform as a Service (PaaS), and CSIRO developed image analysis Software as a Service (SaaS). Figure 1 shows a high-level architectural view of the cloud-based services.

We adopt Galaxy, an open-source, web based platform for data intensive biomedical research, as a workflow engine in our system. Its web portal serves as a Graphical User Interface (GUI) to allow

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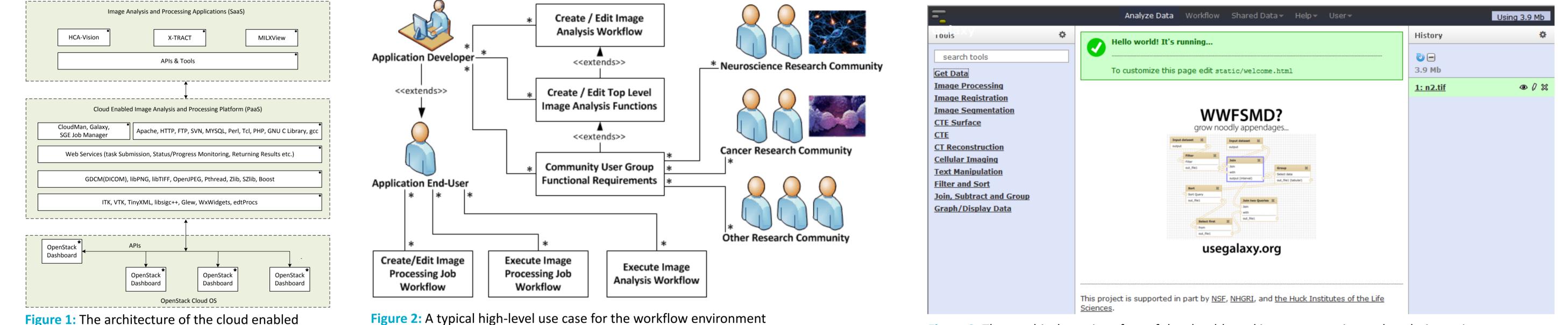
Workflow Management Framework

Using scientific workflow for developing and executing data processing and analysis pipelines has gained wide attentions over the past decades. A workflow is one or more pipelines consisting of a series of functional steps needed to solve a specific problem. Biomedical image analysis is typically conducted using multiple functions and proceeds in a staged fashion with the output of one function used as an input of another. The workflow system provides a flexible approach to both developing and executing image analysis applications and makes use of scalable and cost-effective resources in cloud.

users to add a list of image analysis and processing tools. Each of the tools provides a special user interface to upload image datasets, specify image analysis parameters, and execute the tool. As the user submits a sequence of tasks with the output of one task feeding the input of another, Galaxy automatically records a history log, which is then presented to the user as a graphical workflow. The workflow can be edited and submitted for further executions if needed. A typical high-level use case for the workflow environment is shown in Figure 2.

Biomedical Image Analysis Applications

Our cloud-based services provide a suite of common and advanced image analysis, processing and visualization tools, including (1) Get Data – for a user to upload images, (2) Image Processing, (3) Image Registration, (4) Image Segmentation, (5) Cellular Image Analysis, (6) CT Reconstruction, and (7) Medical Image Analysis. Figure 3 demonstrates the graphical user interface of the toolbox after login to the cloud system. Figures 4 – 9 show the example applications of the cloud-based toolbox in the biomedical image analysis.



History

412.3 Mb

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C	orkflow

Galaxy

· Emboss an image

· Edges find in image

MILXVIEW TOOLS

Image Registration

<u>Thumbnail</u> identify nuclae.

Extract 2D slice from an image

Tools

Get Data Image Processing Analyze Data

Extracted 2D Slices

Genereated 3 PNG output files

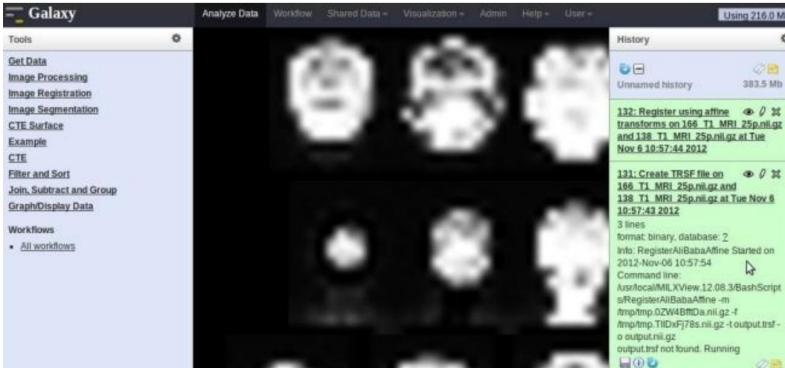
Direct link to the <u>Axial 1 output.png</u> file.

Direct link to the Coronal 1 output.png file Direct link to the Saggital 1 output.png file.

Figure 1: The architecture of the cloud enabled image analysis and processing tools

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rouis 🌣	Find nuclei (version 1.1.0)	History 🌣
search tools	Input image:	<mark>©</mark> — 3.9 Мb
Get Data Image Processing Image Registration Image Segmentation CTE Surface CTE CT Reconstruction Cellular Imaging Find nuclei identify nuclei Find cells from nucleus donut Identify cells given a mask of nuclei Find cytoplasm from nucleus donut Identify cytoplasm given a mask of nuclei Filter objects by morphology filter objects in an image by their morphological properties Find dots Find lines Find dots Find dots Text Manipulation Filter and Sort Join, Subtract and Group Graph/Display Data	1: n2.tif 1: n2.tif Nucleoli radius: 15 Nucleoli radius Largest nuclei radius: 200 Largest nuclei radius Smoothing size: 1.5 Smoothing element size Threshold sensitivity: 0.15 Threshold sensitivity Radius of holes: 0 Radius of holes Split objects: Whether to split objects Select image channel: Red channel Suitable image channel:	3.9 Mb <u>1: n2.tif</u>
	This component finds nuclei in an image of cells	

Figure 4: Parameter panel for nucleus detection tool



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Figure 5: HTMI	nage showin	ng the 2D slice	os extracto	d from a 30	MRIim	າລ
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Figure 3: The graphical user interface of the cloud-based image processing and analysis services

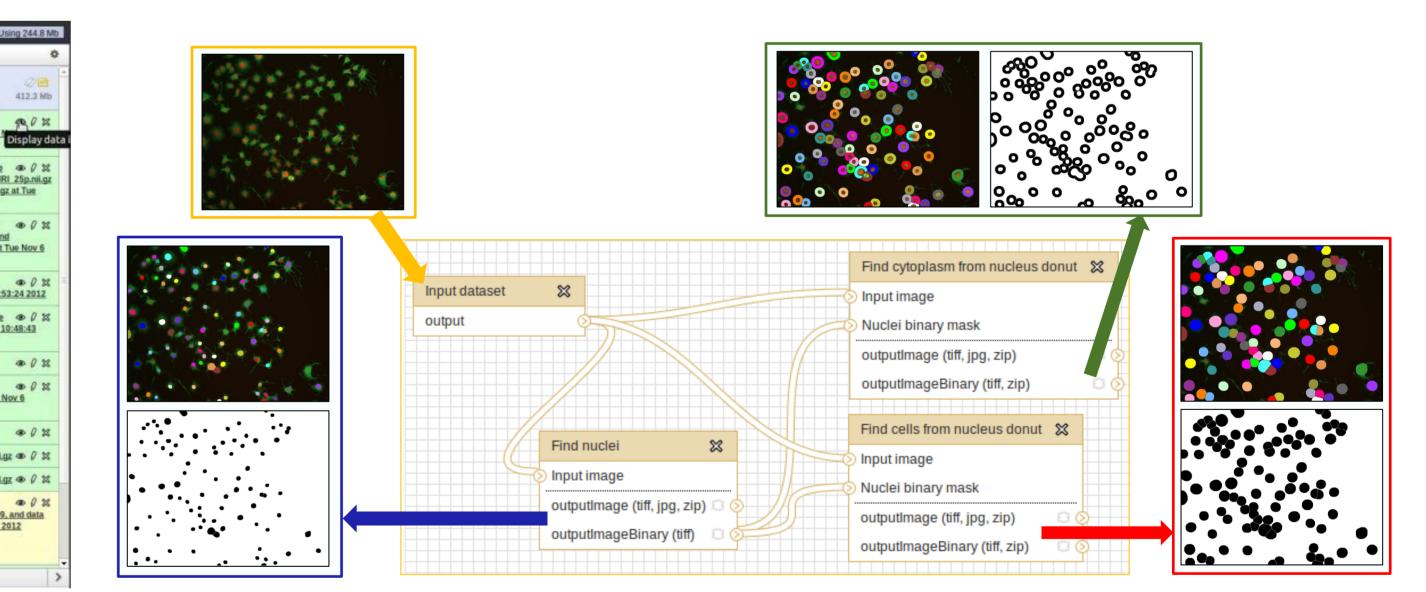
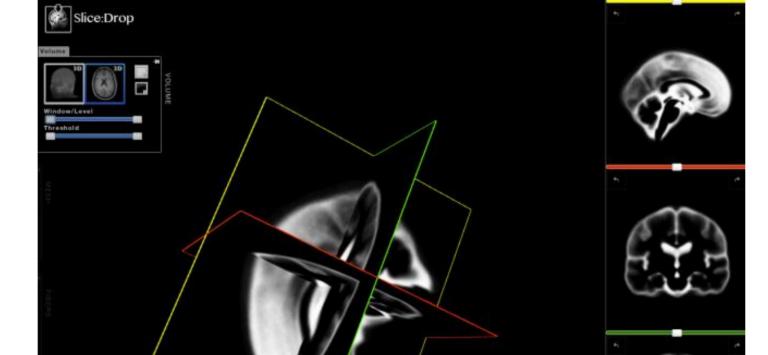


Figure 6: Image analysis workflow for detecting nuclei, cytoplasm and cells



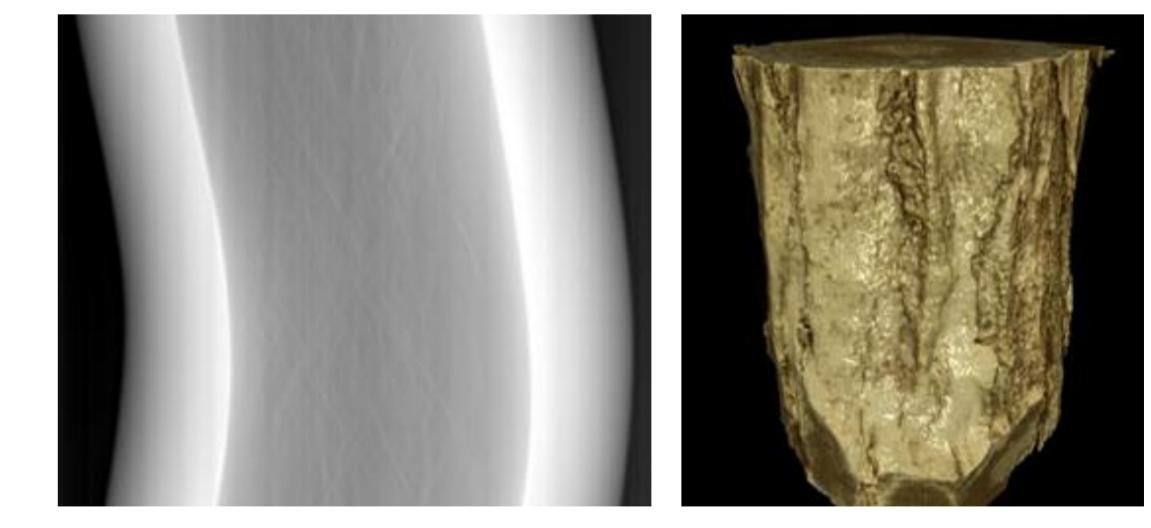




Figure 7: Registration results using affine transformation

Conclusions

Figure 8: Slice: Drop image viewer used in the cloud-based image analysis toolbox

Figure 9: A sample sinogram (left) and the reconstructed 3D image (right) of an acacia plant. Image courtesy of Sherry Mayo and the acacia plant sample provided by Mel Linton (CSIRO)

We have presented the architecture, design and implementation of the cloud computing services for biomedical image analysis, which is running on a national cloud infrastructure. The toolbox provides an easy way for various user communities to access the well-established image processing and analysis algorithms and software as services without knowing and caring about the details of these algorithms and how and where they are executed. Our preliminary experimental results have shown that the toolbox offers a powerful new resource for scientists, due to its scalability, nimbleness and cost-effectiveness.

FOR FURTHER INFORMATION

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Scan the tag to see more information on Quantitative Imaging Group of CSIRO Mathematics.

Informatics & Statistics.

REFERENCES

NeCTAR: http://nectar.org.au HCA-Vision : http://www.hca-vision.com X-Tract: http://www.ts-imaging.net MILXView: http://research.ict.csiro.au/soLware/milxview Galaxy: http://galaxyproject.org/

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