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### Introduction

Information Operations (IO) requires the integrated analysis of qualitative and quantitative data to characterize and assess the effects of candidate strategies for a target environment. The collaborative integrative analysis process currently employs theoretical and doctrinal best practices within IO analysis Communities of Interest (COI). Within this process, understanding and implementing effective combinations of data and analytic techniques is critical to achieving IO goals. This Innovation project investigated and developed a prototype artificial intelligence (AI) workflow engine based on game theory best practices, utilizing an open-source scientific workflow management system to provide flexibility and interoperability. Extensions of this engine can use historically logged processes to assist the analyst with use of various analytic techniques.

### Approach

The GameVISION project examined a step forward with the InA process, with an emphasis on the process itself and the use of analytic techniques within IO analysis. GameVISION possesses the following components:

#### 1. Scientific Workflow Management System

GameVISION takes advantage of the open-source Kepler Project scientific workflow application. Kepler is built from the Ptolemy II framework for actor-oriented design, and has several useful capabilities, including:

- Can build analytic workflows without strong programming background
- Flexible tools for accessing and executing complex analysis on scientific data
- Drag-and-drop user interface
- Can interface with web services and query databases
- Can interface with Matlab, R, C, and Java code
- Users can create their own actors

#### 2. Analytic Component Library

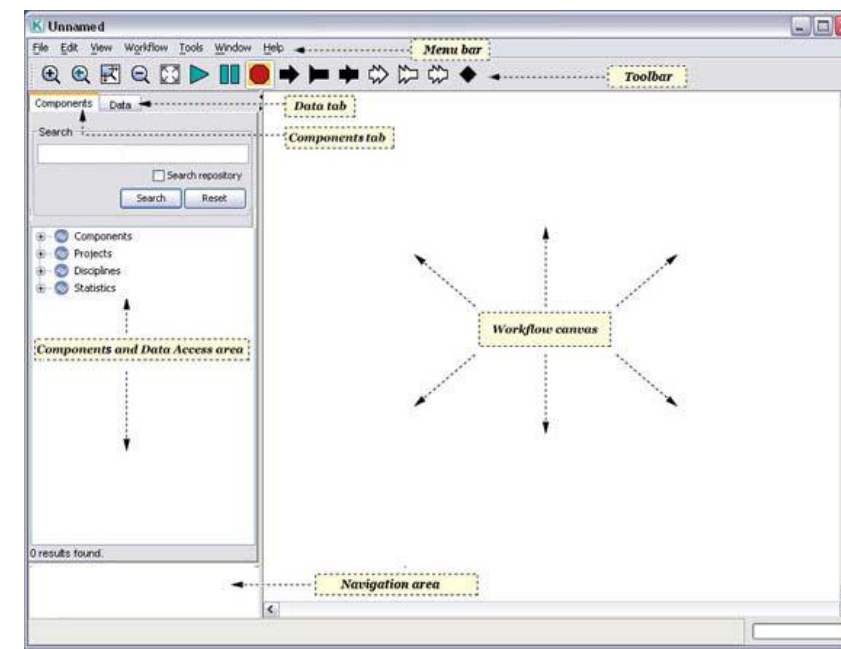
A library of analytic techniques (sub-workflows) were created, from which users can build complete workflows using the drag-and-drop interface without programming.

#### 3. Underlying Analytic Algorithms

Each analytic technique utilizes a combination of built-in Kepler actors and code using the R statistical programming language. Algorithms within the library were built to perform clustering, regression, correlations, plotting, and social network analysis.

#### 4. Game Theory Modeling

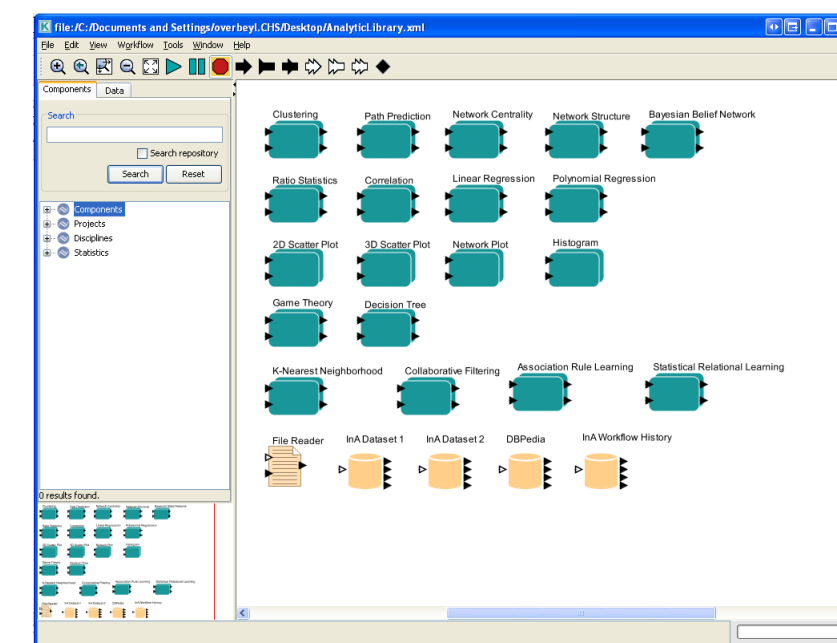
To incorporate game theory, an analytic technique was built as a part of the library to utilize a game theoretic models.



Screenshot of the Kepler interface.

### Results

An initial analytic component library was built within Kepler for IO quantitative analytics. A screenshot of this library is shown below.

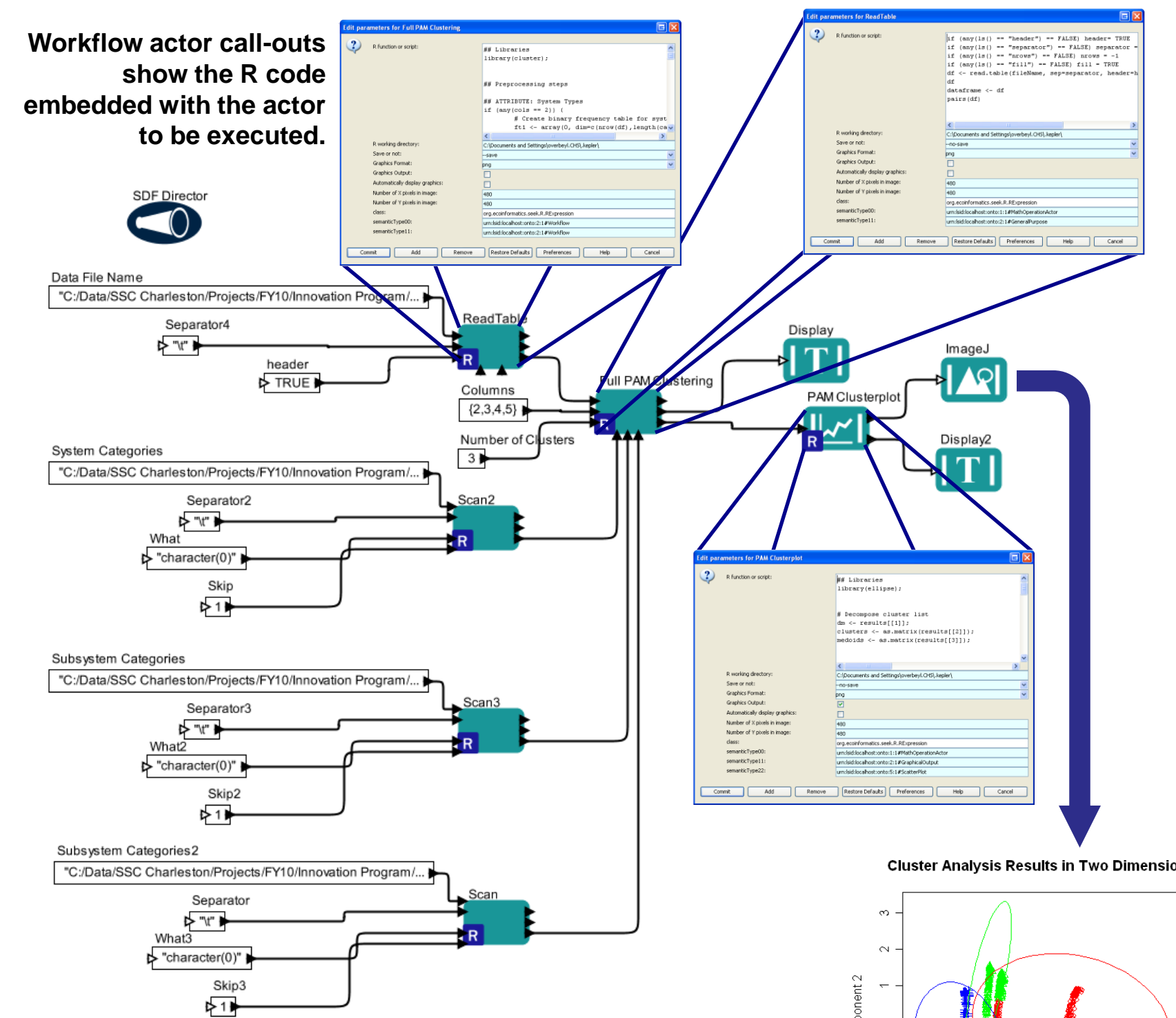


Screenshot of the GameVISION analytic technique library.

#### Example Analytic Workflow: Clustering

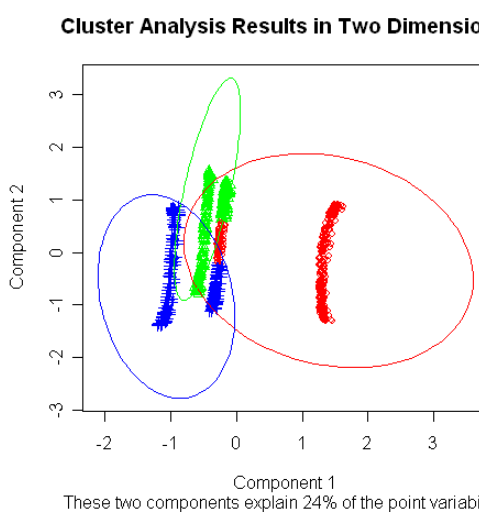
The example workflow below takes inputs from a data file, and then performs mixed-type partitioning around medoids (PAM) clustering on the data, and outputs a two-dimensional representation of data similarity (based on classical multi-dimensional scaling) and cluster belonging. The workflow and example outputs are displayed below.

Workflow actor call-outs show the R code embedded with the actor to be executed.



Above: Example workflow. PAM clustering example.

Right: Clustering output based on realistic mixed-type data and three clusters. Cluster belonging is represented by color. 99% of the data covariance for each cluster is within the colored ellipses.



### Conclusions & Future Work

The GameVISION project investigated the use of scientific workflow frameworks to develop an analytic library and process builder for use in IO integrative analysis. Several analytic components were developed in the Kepler framework as an initial library. Using this type of framework has advantages related to composable, customization, collaborative sharing of workflows, and ability to interface with several programming languages and data sources. A disadvantage is diminished performance (speed) caused by the extra scientific workflow layer. The GameVISION software was initially investigated as potential leap-ahead technology for the Virtual Integrated Support to the IO Environment (VISION) program, but is applicable for other IO integrative analysis uses as well.



### References

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