The Rim of the Wine Glass: a comparative regional study of vineyard micro-climates in the Asia-Pacific

Abstract: This paper describes a vineyard micro climate monitoring and modelling research programme in the Asia-Pacific Region where climate, atmosphere, plant and soil sensors are used to gather data and using a real-time telemetry architecture for transmission to a central server and are computationally modeled using a variety of combinatorial statistics and other computational methods to analyze the dependency-relationships within the set of variables. The purpose of this analysis is to develop optimal location-condition scenarios and predict crop impact-influence situations such as frost, irrigation, time-to-prune and time-to-harvest. Data is gathered from various countries and in particular from the Ajimu wine site in Japan. Undergraduate and graduate students at APU have joined the effort to collect and analyze this data.

Key Words: Environmental modelling, wine data visualisation

1. Wine Consumption in the Asia-Pacific Region

1.1. While global consumption has only risen by an average one per cent annually in recent years, Asia's wine consumption is rising by nearly eight per cent. Given that consumer research indicates a worldwide spend of more than US$ 100 bn on wine in 2006, this portrays a significant impact for the Asia-Pacific Region, which includes Japan, China, SE-Asia, Australia, and New Zealand. An assumed global wine consumption to exceed 26.2 Billion litres by 2010 helps to put into perspective the vast operational scale relating to grape growing and wine production[i].

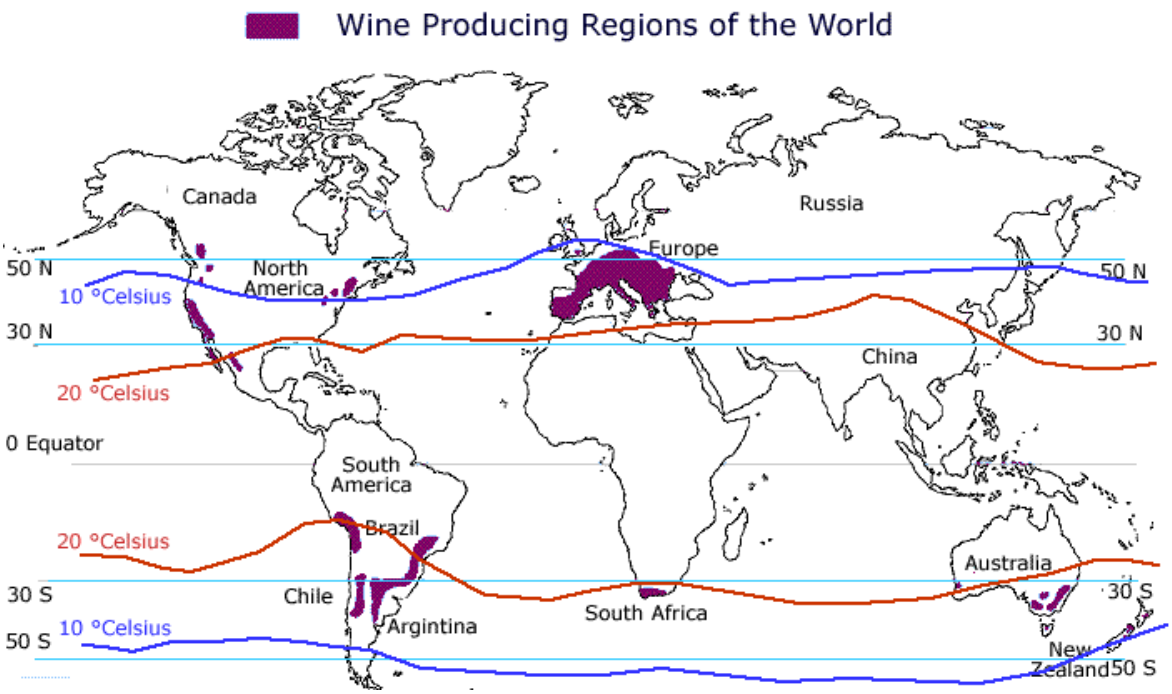


Figure 1: *World's major wine producing regions and the temperature zones in the northern and southern hemispheres that favor grapevine growing and wine production. Japan falls squarely within the most fertile longitudes.*

2. Computational models to relate environmental factors that influence grape growing and wine quality.

The concept for this research, the broad programme titled *Eno-Humanas,* seeks to develop computational models relating to environmental factors that influence grape growing and wine quality. The data set includes those precise data values collected from atmospheric, climatic, terrain and plant sources as well as imprecise data values gathered from human sensory perceptions of taste, flavor, complexity and structure of the wine that is produced. The sensory data is may be referred to as *fuzzy data* and comprises vector elements capable of being described in mathematics as *rough sets*[ii] . See figure 2.

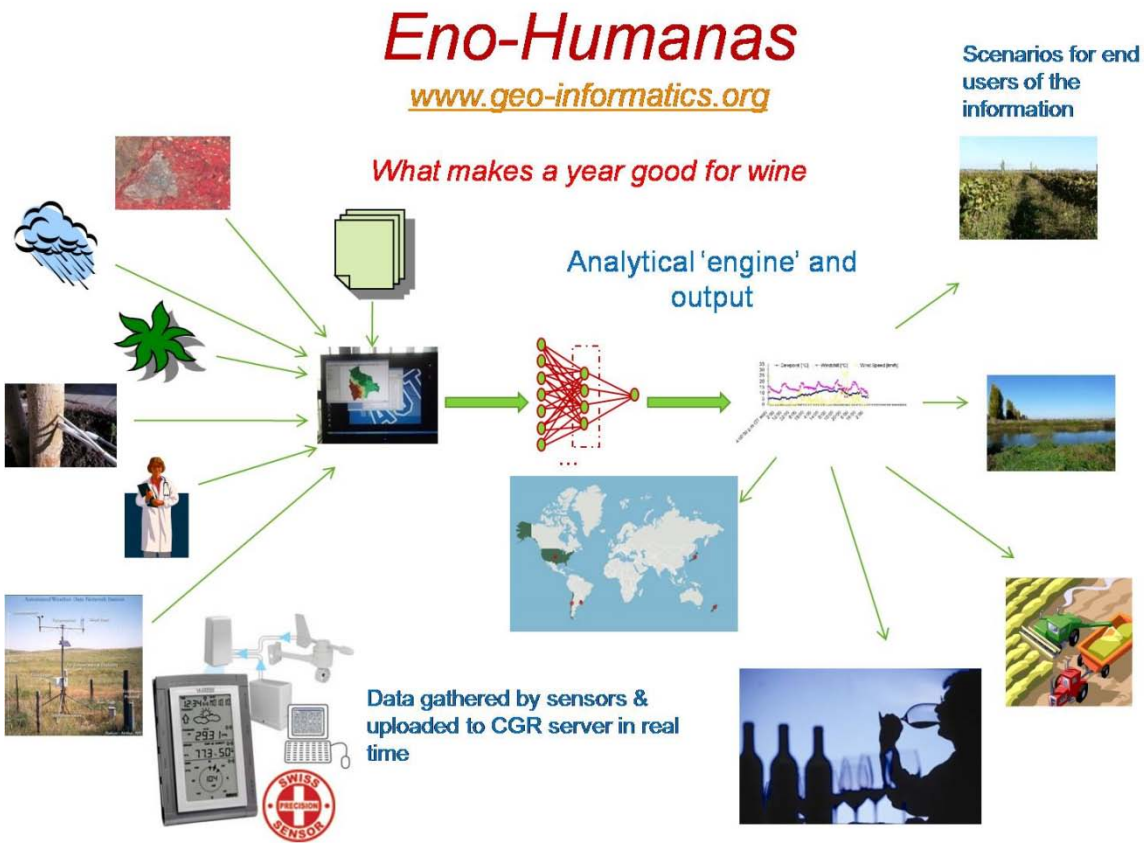


Figure 2: *The Eno-Humanas project principal components, their interactions and data flow through for prototype implementation.*

Research Methods

3. Overview of data collection.

3.1 Precise Data

A wireless sensor network (WSN) has been installed in several wine producing countries. Nine vineyards were chosen in four countries (Chile, Uruguay, Japan and New Zealand, see www.geo-informatics.org). One sensor node for each vineyard has been installed at initial stage of WSN implementation. (see figure 3)

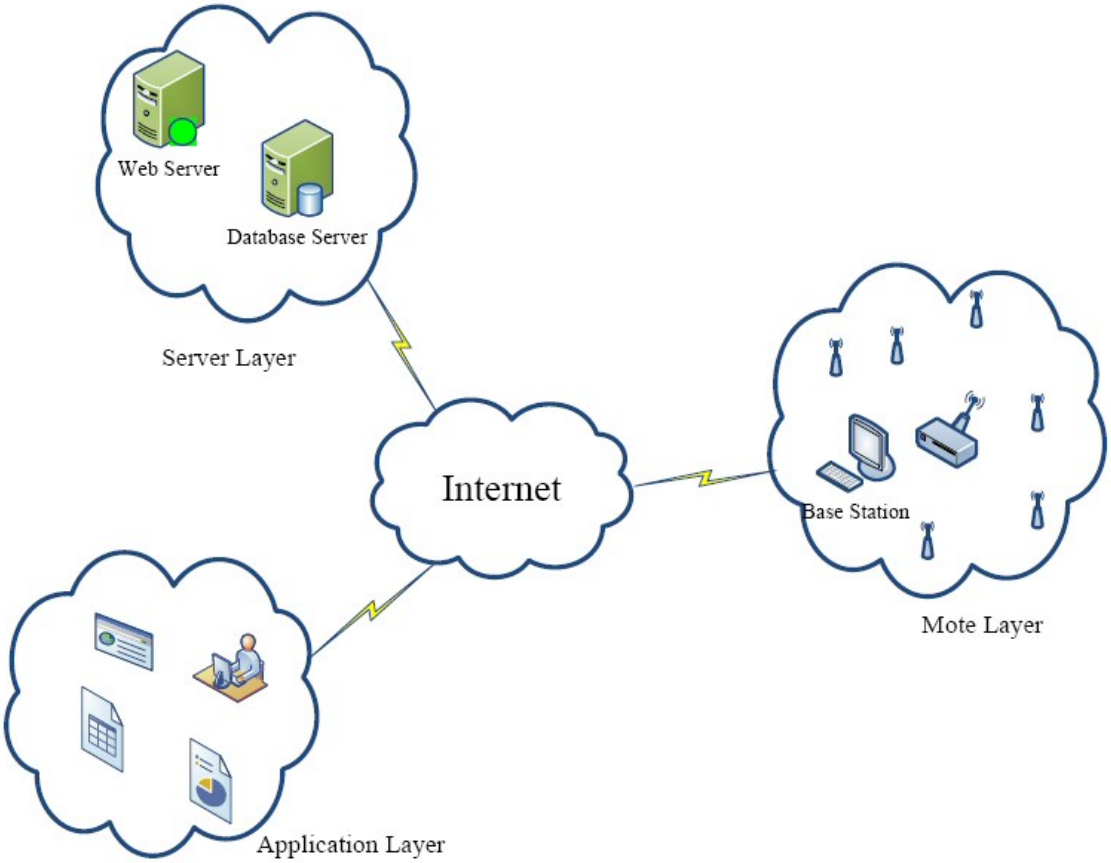


Figure 3: *System architecture: Schematic diagram of WSN layout for modeling the influence of microclimate effects in weather, atmospheric and environmental conditions and on grapevines within a vineyard.*

The WSN transmits real time data collected through remote, wireless telemetry devices via repeaters, gateways and the Internet to a central sever for display and comparative analysis on the variability in climate change across the world's major wine regions and grapevine varieties. Data on soil, landscape, aspect, sunshine, cloud effects as well as pruning and harvest will be incorporated from satellite and other grid based data sources

3.2 Fuzzy (imprecise) Data Collection

In addition to the WSN data sommelier comments on wines, vintage rating, and price are analysed.

4. Web Access to WSN Data

Data stored in an SQL database is readily available for further analysis. A web application was developed enabling users to access the WSN data over the internet.

This interface was written in ASP.NET and C# to allow users interactively chose desired parameters and plot the results. Figure 4 shows a screenshot of a database query to visualize temperature and humidity from a sensor node in a chosen vineyard.

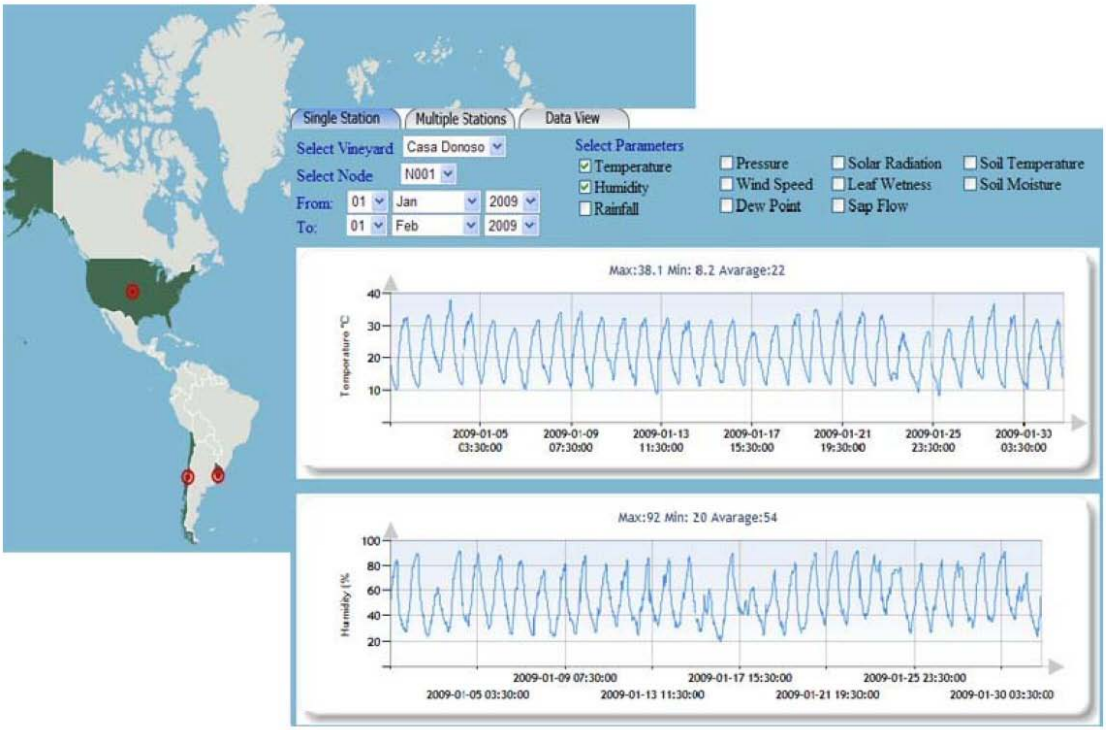
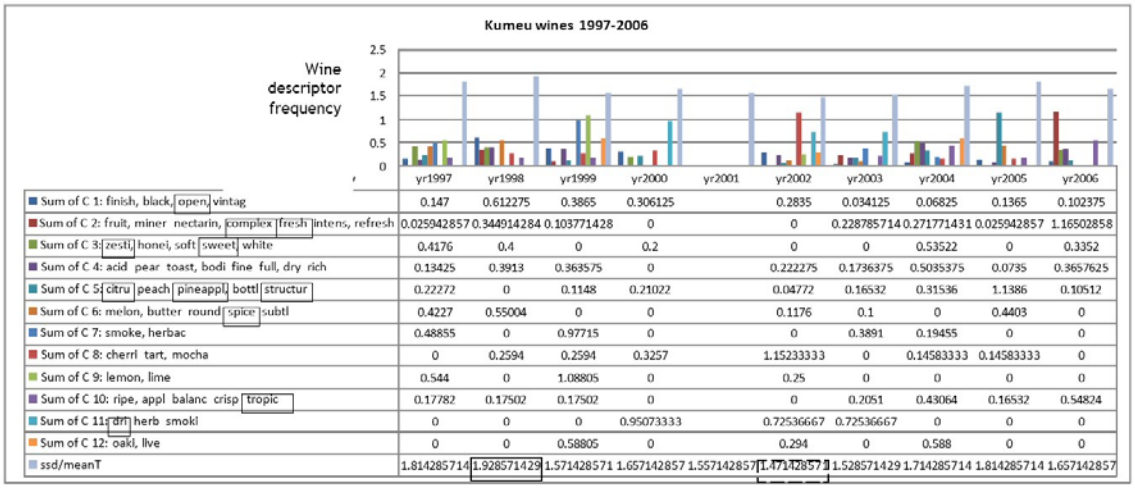


Figure 4: *(source: http://dev.geo-informatics.org/WS/NZData.aspx)*

Screenshot of a web-based visualization of Temperature and Humidity obtained from a WSN located in Fondo Casa Donoso, a vineyard in the Maule Region, Chile.

5. Data Modelling and Visualisation

Data depiction methods have been used to provide visualization to illustrate data dependencies. GRC research thus far conducted in this regard using Kohonen WEBSOM and statistical methods produced promising results in visualising the correlations between the vintage-to-vintage variability (climate change) on wine quality with an example data set from Kumeu River Winery in northern New Zealand (Figure 5).



	yr1997	yr1998	yr1999	yr2000	yr2001	yr2002	yr2003	yr2004	yr2005	yr2006
Sum of C 1: finish, black, open, vintag	0.147	0.612275	0.3865	0.306125		0.2835	0.034125	0.06825	0.1365	0.102375
Sum of C 2: fruit, miner nectarin, complex fresh intens, refresh	0.025942857	0.344914284	0.103771428	0		0	0.228785714	0.271771431	0.025942857	1.16502858
Sum of C 3: zesti, honei, soft sweet white	0.4176	0.4	0	0.2		0	0	0.53522	0	0.3352
Sum of C 4: acid pear toast, bodi fine full, dry rich	0.13425	0.3913	0.363575	0		0.222275	0.1736375	0.5035375	0.0735	0.3657625
Sum of C 5: citru peach pineappl, bottl structur	0.22272	0	0.1148	0.21022		0.04772	0.16532	0.31536	1.1386	0.10512
Sum of C 6: melon, butter round spice subtl	0.4227	0.55004	0	0		0.1176	0.1	0	0.4403	0
Sum of C 7: smoke, herbac	0.48855	0	0.97715	0		0	0.3891	0.19455	0	0
Sum of C 8: cherri tart, mocha	0	0.2594	0.2594	0.3257		1.15233333	0	0.14583333	0.14583333	0
Sum of C 9: lemon, lime	0.544	0	1.08805	0		0.25	0	0	0	0
Sum of C 10: ripe, appl balanc crisp tropic	0.17782	0.17502	0.17502	0		0	0.2051	0.43064	0.16532	0.54824
Sum of C 11: drn herb smokl	0	0	0	0.95073333		0.72536667	0.72536667	0	0	0
Sum of C 12: oakl, live	0	0	0.58805	0		0.294	0	0.588	0	0
ssd/meanT	1.814285714	1.928571429	1.571428571	1.657142857	1.557142857	1.471428571	1.528571429	1.714285714	1.814285714	1.657142857

Figure 5: *Histogram of Kumeu (New Zealand) wine descriptor frequencies in each year from 1997 - 2006, obtained from 12 clusters of a SOM (of 45 nodes and clustered using SOM cluster indicator) created with 51 variables .*

6. **Frost Prediction**

One of the principal aims of this project is to provide predictive models for micro-level forecast of frost events. Initially this analysis used historical meteorological databases from large area monitoring, principally intended for weather forecasting as shown in the figure below .

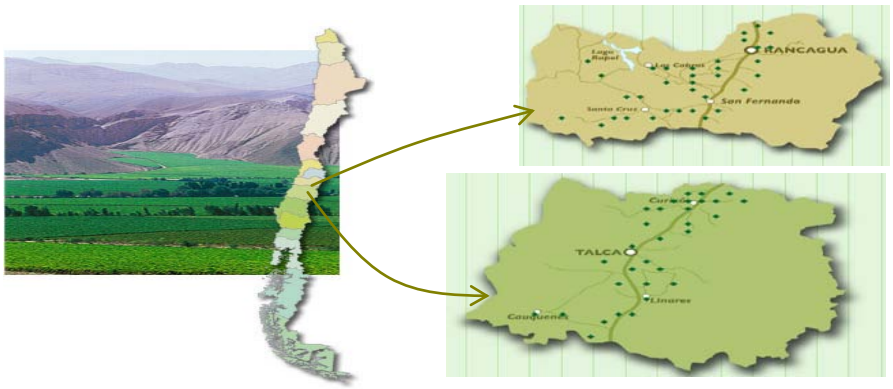


Figure 6: *Location of the two major grape growing regions in Chile*

From this historical data for each particular station we applied various visualization techniques after analysing the relationship between the variables (temperature, humidity, wind speed and direction, etc.)

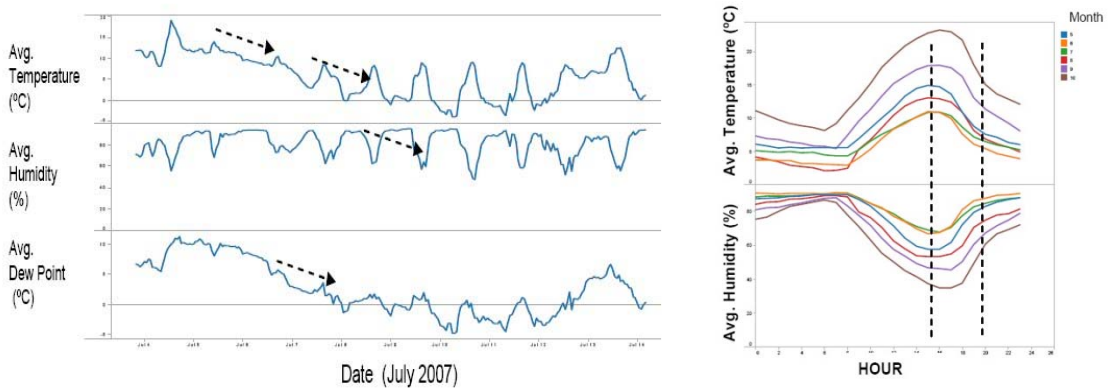


Figure 7: *Examples of visualization, (a) Temperature, Humidity and Dew Point average between July 4 and 14; (b) Temperature and Humidity average for every hour in each month.*

The analysis techniques employed consider inter alia the use of neural networks, which in the case of the preliminary analysis used Self Organizing Maps (SOMs).

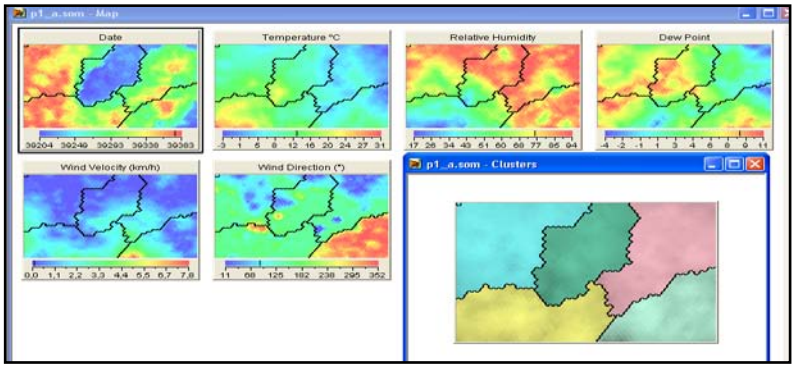


Figure 8: *SOM analysis considering the following variables: date, temperature, relative humidity, dew point, wind velocity and direction.*

7. Discussion and Recommendations

With publications thus far listed at[iii], the research described here is ongoing. It has numerous facets and currently engages several academics and scientists, research students and industry participants. It is hoped to gather sufficient data to populate reliable predictive models for such vineyard management issues as frost and irrigation, fungus growth situations, pruning and harvesting optimization scenarios. Moreover, it expects to continue contributing to the state-of-knowledge regarding environmental influences factors for grape growth and wine production through the analysis of data generated from this study and other related sources.

8. Conclusion

The authors anticipate that the contribution of this international research collaboration and this paper will inform and assist the development of thought and methodological approaches to research that relates to the Asia-Pacific Region.

References:

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i Elise Shin, 2008, Wine With Asian Food in Asian Week The voice of Asian America, April 2, 2008. www.asianweek.com/2008/04/02/wine-pairing-tasting-asian-food/#

ii Slezak, D., G. Wang., M. Szczuka., I. Duentsch., and Y. Yao., (Eds.) Rough Sets, Fuzzy Sets, Data Mining, and Granular Computing in proceedings of the 10th International Conference, RSFDGrC 2005, Regina, Canada, August 31 - September 3, 2005, Part I Series: Lecture Notes in Computer Science, ISBN: 978-3-540-28653-0 Vol. 3641 Volume package Rough Sets, Fuzzy Sets, Data Mining, and Granular Computing 2005, XXIV, pp 742 ISBN: 978-3-540-28653-0

iii Geoinformatics Research Centre, www.geo-informatics.org/publications.aspx