

**ADVANCES
IN STUDIES
ON RISK
ANALYSIS
AND
CRISIS RESPONSE**

**PROCEEDINGS OF THE FIRST
INTERNATIONAL CONFERENCE
ON RISK ANALYSIS
AND CRISIS RESPONSE,
SEPTEMBER 25-26, 2007,
SHANGHAI, CHINA.**



**Advances in Studies on
Risk Analysis and
Crisis Response**

Proceedings of the
1st International Conference on

Risk Analysis and Crisis Response

September 25th – 26th, 2007
Shanghai, China

Edited by

Chongfu Huang

Christopher Frey

Jiali Feng



ISBN 978-90-78677-03-1

Research (ISSN

ling and repro-
al approaches
areas, including

ne technology,
ch in computer
me time, com-
fields allowing

aling with and
ce in artificial

of intelligence
ngful data from

chine learning
onomous sys-
uting * Biologi-
logics * Neural
ation sciences
* Datamining,

France.

ated, stored or
anical, photo-
ublisher.

The First International Conference on Risk Analysis and Crisis Response

September 25th – 26th, 2007, Shanghai, China

- Theme** : Theories and Applications of Risk Analysis and Crisis Response
- Organized By** : Risk Analysis Council of China Association for Disaster Prevention
- Hosted By** : Shanghai Maritime University
- Sponsored By** : National Disaster Reduction Center, Ministry of Civil Affairs of China
Society for Risk Analysis
Society for Risk Analysis-Europe
Society for Risk Analysis-Japan
- Supported By** : National Natural Science Foundation of China



ORGANIZATION

- General Chair: — **Chongfu Huang**, Beijing Normal University, China
Co-Chairs: — **Christopher Frey**, North Carolina State University, USA
— **Jinren Ni**, Peking University, China
— **Zhongzhi Wu**, China Academy of Safety Science and Technology, China

Organizing Committee

- Organizing Chair: — **Youfang Huang**, Shanghai Maritime University, China
Co-Chairs: — **Xiaofeng Wang**, Shanghai Maritime University, China
— **Dazheng Xu**, Shanghai Maritime University, China
Members: — **Weiping Chen**, Shanghai Maritime University, China
— **Weijiong Chen**, Shanghai Maritime University, China
— **Guangzhong Liu**, Shanghai Maritime University, China
— **Weijian Mi**, Shanghai Maritime University, China
— **Linchi Qu**, Shanghai Maritime University, China
— **Chaojian Shi**, Shanghai Maritime University, China
— **Xing Shi**, Shanghai Maritime University, China
— **Leping Xu**, Shanghai Maritime University, China
— **Yingjie Xiao**, Shanghai Maritime University, China
Secretary: — **Yongsheng Yang**, Shanghai Maritime University, China
— **Chunlin Hou**, Shanghai Maritime University, China

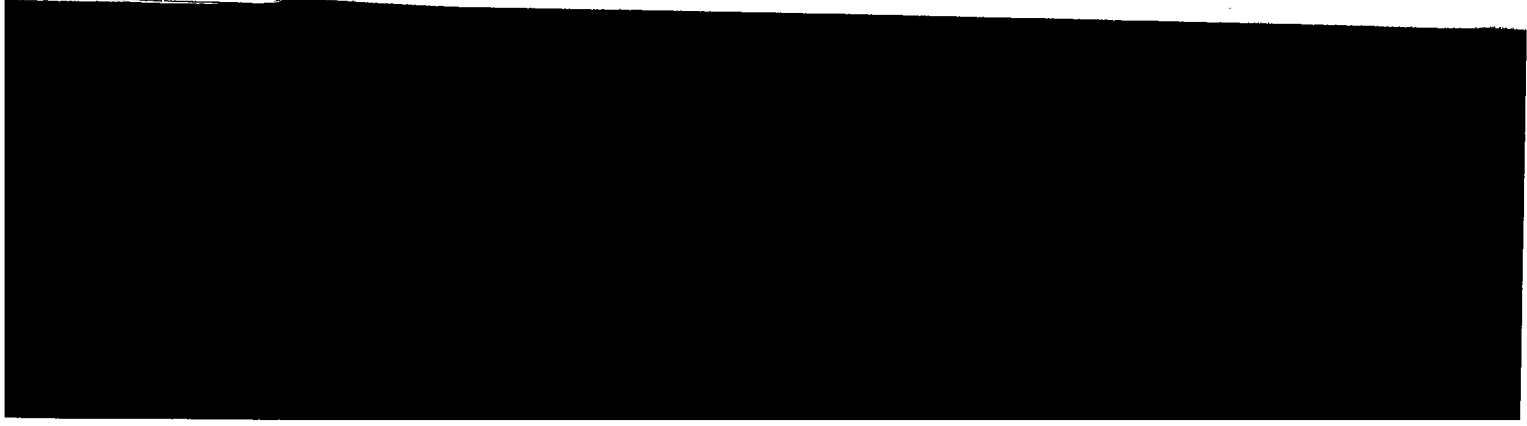
Programme Committee

- Programme Chair: — **Jiali Feng**, Shanghai Maritime University, China
Co-Chairs: — **Olivier Salvi**, INERIS (Institute National de l'Environnement Industriel et des Risques), France
— **Hiroyuki Kameda**, Kyoto University, Japan
— **Zongfang Zhou**, University of Electronic Science & Technology of China, China
Members: — **Shoji Tsuchida**, Kansai University, Japan
— **Mohan Balagopalan**, South Coast Air Quality Management District, USA
— **Roberto Bubbico**, University La Sapienza, Italy
— **Changchuan Chan**, National Taiwan University, Taiwan, China

- **Peg Coleman**, Syracuse Research Corporation, USA
- **Yongsheng Ding**, Donghua University, China
- **Michail Faleev**, Ministry of Russian Federation, Russia
- **Tee Guidotti**, The George Washington University, USA
- **Hirofada Hirose**, Tokyo Woman's Christian University, Japan
- **Vincent Ho**, Kowloon-Canton Railway Corporation, Hong Kong, China
- **Zhiguo Huo**, Chinese Academy of Meteorological Sciences, China
- **Saburo Ikeda**, Tsukuba University, China
- **Jean-Marie Jacques**, University of Louvain, Belgium
- **Cengiz Kahraman**, Istanbul Technical University, Turkey
- **Jingyi Li**, Lanzhou University, China
- **Xu Li**, Fudan University, China
- **Anlin Liu**, China Life Insurance (Group) Company, China
- **Xilin Liu**, Sun Yat-sen University, China
- **Siuming Lo**, City University of Hong Kong, China
- **Andre Maisseu**, University of Paris "Pantheon - La Sorbonne", France
- **Masaru Matsumoto**, Zhong Sheng International Insurance Brokers Co., LTD., China
- **Scira Menoni**, Politecnico di Milano, Italy
- **Shinsuke Morisawa**, Kyoto University, Japan
- **Ramond Neutra**, California Environmental Health Investigations Branch, USA
- **Norio Okada**, Kyoto University, Japan
- **Marc Poumadere**, Groupe de Recherche sur RID, France
- **Guosheng Qu**, National Earthquake Response Support Service, China
- **Luchuan Ren**, China Earthquake Networks Center, China
- **Ortwin Renn**, University of Stuttgart, Germany
- **Teruko Sato**, National Research Institute for Earth Science and Disaster Prevention, Japan
- **Jo Anne Shatkin**, The Cadmus Group, Inc., USA
- **Phillip C.Y. Sheu**, University of California — Irvine, USA
- **Maryline Specht**, University Paris 5, France
- **Pierre Syci**, South Coast Air Quality Management District, USA
- **Yongjing Tang**, Tongji University, China
- **Andrea Thalmann**, T-Mobile Germany, Germany
- **Fabienne Vallee**, The Science Park of Brest Iroise, France
- **Dong Wang**, Nanjing University, China

ration, USA
ina
ation, Russia
iversity, USA
1 University,
poration,
ological
n, Belgium
ersity, Turkey
mpany, China
China
ion - La
ional Insurance
in
health
ir RID, France
ase Support
Center, China
ny
Earth Science
USA
Irvine, USA
ment District,
any
roise, France

- **Xiaofeng Wang**, Shanghai Maritime University, China
- **Yiming Wei**, Institute of Policy and Management, China
- **Kuenyuh Wu**, National Health Research Institutes, Taiwan, China
- **Libin Xie**, Administrative Centre of Panzhuhua's Agenda 21, China
- **Jiquan Zhang**, Northeast Normal University, China
- **Yanqing Zhang**, Georgia State University, USA
- **Jay Zhao**, Toxicology Excellence for Risk Assessment, USA



A Support Vector Machine Model for the Situation Awareness System

Bo Liu^{1,2} Jie Lu^{2*} Guangquan Zhang² Zhifeng Hao¹ Ya Gao²

¹ College of Computer Science and Engineering, South China University of Technology, Guangzhou 510640, P. R. China

² Faculty of Information Technology, University of Technology, Sydney, PO Box 123, NSW 2007, Australia
corresponding author email: jielu@it.uts.edu.au

Abstract

Situation awareness (SA) is to describe the challenges faced by us when interacting with controlled systems or work environments through technological interfaces. This paper first gives a mathematical description for SA. It then classifies all the possibilities of SA functions into classification and regression problems which can be readily resolved by some machine learning tools. Based on the results, this paper constructs a support vector machine model to deal with the two types of issues of SA.

Keywords: Situation Awareness; Machine Learning; Support Vector Machine, Information Systems.

1. Introduction

The enhancement of operators' situation awareness (SA) [1] has been becoming a major design goal for those developing operator interfaces, automation concepts and training programs in a wide variety of fields, including aircraft, air traffic control, power plants, and advanced manufacturing systems. This dramatic growth in interest in SA, beginning in the middle of 1980's and accelerating through the 1990's, was spurred on by many factors, chief among them the challenges of a new class of technologies.

Although there are many dimensions to SA, and its functional role depends on the specifics of the environments and tasks, continued advances in understanding and supporting SA are almost sure to depend on advances in measurements. Salas [2] summed up the situation well: "a central problem in understanding situation awareness is the lack of well-developed measurement tools". In human factors, one of the most influential perspectives on SA has been put forth by Endsley, who has studied the phenomenon within the contexts of automation [3], air traffic control [4], and naturalistic decision making [5], among others. Informally, Endsley notes that SA concerns "knowing what is going on". More precisely,

SA is defined as "the perception of the elements of the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future". Endsley's definition describes SA as a three-level model involving elements of perception, comprehension, and projection. In this model, Endsley describes, at Level one, SA as knowledge that results from the perception of disjointed "elements" in the environment, in which an element is equated with environmental objects and attributes. At Level two, SA typified as a mental picture or model, is described as comprehension of the situation, or an understanding of its current significance. At Level three SA is described as the ability to predict future states of Level one's elements. Other researchers in this area have also presented qualitative, cognitive models for SA, defining it as a mental picture or an internal product. For example, in the context of land navigation, Wesler [6] equated SA to the contents of short-term memory. In aviation, Gibson and Garrett [7] described SA as a Gestalt-like appreciation of a situation, and Taylor [8] described SA as a "veridical model of reality".

In order to assess and control SA more expediently, this study first gives a description of SA mathematically. It then classifies all the possibilities of SA functions and elements into two typical problems: classification and regression problems. Obviously the two types of problems can be readily resolved by existing machine learning tools. Support vector machine (SVMs) model [10] has been introduced for solving pattern recognition problems and function approximations because of their superior performance [10, 11]. SVMs are developed based on the idea of structural risk minimizations (SRM) [12, 13] which shows that generalization errors are bounded by the sum of training errors and a term depending on the Vapnik-Chervonenkis (VC) dimension of the learning systems. In the SVMs, the original input space is mapped into a high dimensional feature space via a certain kernel function to avoid the highly and costly computation of the inner product of two vectors. In

e Situation

Gao²
Guangzhou 510640, P. R.
, NSW 2007, Australia

tion of the elements of the
ne of time and space, the
ning, and the projection of
ire". Endsley's definition
-level model involving
prehension, and projection.
ribes, at Level one, SA as
rom the perception of
environment, in which an
vironmental objects and
SA typified as a mental
l as comprehension of the
anding of its current
SA is described as the
of Level one's elements.
rea have also presented
for SA, defining it as a
product. For example, in
a. Wesler [6] equated SA
m memory. In aviation,
ibed SA as a Gestalt-like
nd Taylor [8] described
ality".
nd control SA more
ives a description of SA
es all the possibilities of
to two typical problems:
problems. Obviously the
be readily resolved by
tools. Support vector
has been introduced for
problems and function
ir superior performance
d based on the idea of
(SRM) [12, 13] which
ors are bounded by the
term depending on the
mension of the learning
original input space is
nal feature space via a
d the highly and costly
luct of two vectors. In

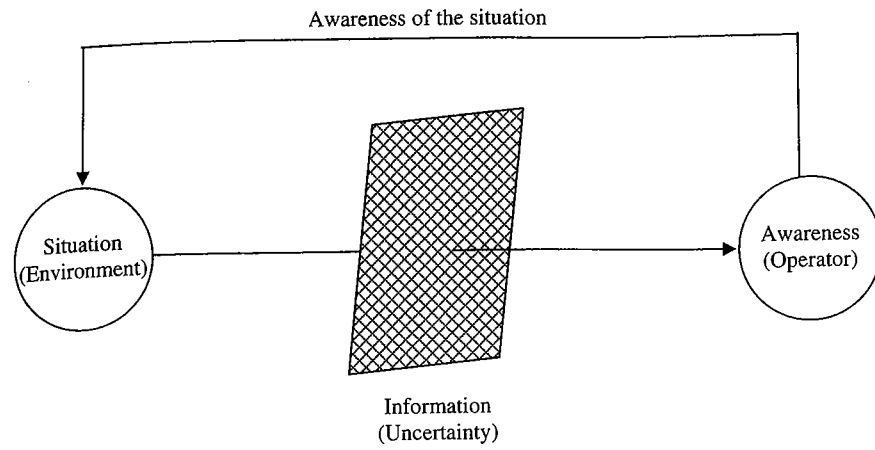


Fig. 1 A system and ecological framework for modeling the judgment or mediated SA

this feature space the optimal separating hyperplane with maximal margin will be determined to maximize the generalization performance of the tool [14]. SVMs can be used to solve both classification and regression problems for us.

The rest of the paper is organized as follows: in Section II, we will describe SA modelling and related measurement method, Machine Learning Tools for SA will be presented in Section III. The fundamental concepts of SVC and how SVC can solve classification and regression problems in SA will be discussed in Section IV. Section V summaries the study.

2. Situation Awareness Modelling and Measurement

In this section, we will introduce the notion of SA at first. Brunswik's [15] perspective on judgment under uncertainty is the initial basis for a model of the judgmental components of situation awareness. Let us focus on the Fig. 1 which describes the basic idea of both Brunswik's theory of judgment and interface-mediated situation awareness.

The left side of Fig. 1 denotes a situation or an environment, and the right side of the figure depicts awareness, or what Brunswik referred to as the organism. Mediating the situation-awareness relationship, or generally the environment-organism relationship, is both information and the uncertainty that accompanies it. In the practical applications, one of the most important issues is how to analyze the situation around us and how to utilize an efficient

mathematic model to measure them, and then make the corresponding decision making to deal with the possibly alternative situations. It must be noted that the usual methods adopted are to measure the quality of a judgement in terms of a correspondence between the judged situation and the actual, environmental situation, measured by linear association, or establish some mathematics models, however, in generally, we don't exactly know what relationship between the situation and the judged situation; therefore, the suitable mathematics models are usually hard to be established.

3. Constructing Machine Learning Tools for Situation Awareness

In recent years, the machine learning tools including support vector machine have been developed aiming at resolving little samples problems. In these tools, the process has been split into a training step and a testing step, among the training step the machine learning tools are trained by the training samples, as a result, the parameters in the tools are obtained and the corresponding simulating function is formed. The testing course is to verify the performance of the tools so that which can be utilized future applications. In the following paragraph, we will describe the proposed approach to deal with the SA system.

First of all, let us focus on the situation or environment around us, it is well known that the ingredients which affect the final making-decision consist of many factors, and all the factors involved in the situation should be considered, otherwise the final awareness results will reflect on the warp. In order to

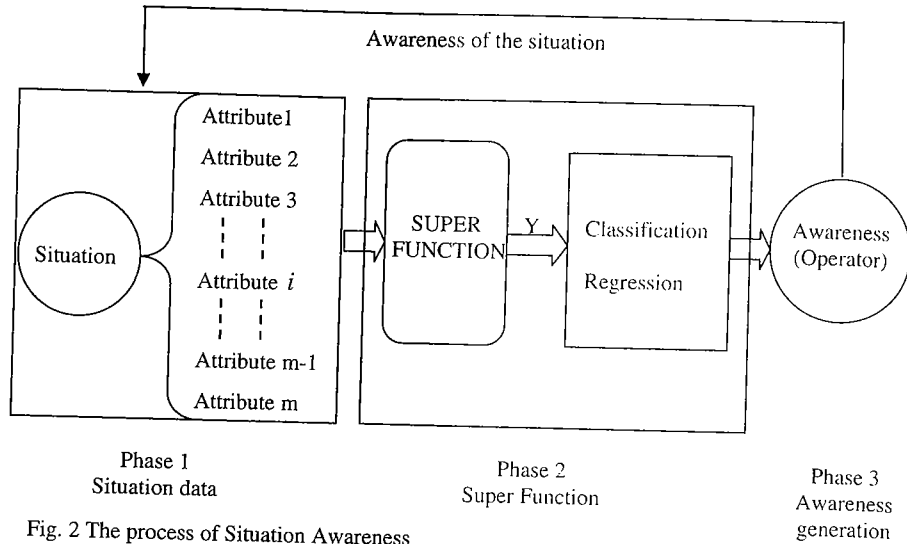


Fig. 2 The process of Situation Awareness

depict the situation more reasonably and roundly so that they can be implemented into the future machine learning tools, the mathematic language will be utilized to present them. We know the situation may consist of thousands of factors, however only parts of which affect the final awareness, in the following analyses we just need to focus on these factors. Assume there are *m* factors in the situation affecting our final making decision; in mathematic method the *m* factors can be regarded as *m* variables. However, the data type of the *m* variables can be integer, decimal fraction, continuous-valued or natural language description. In order to apply the machine learning tool to resolve the problem, the data type of the *m* variables should be numerical value, for the variable such as integer and decimal fraction type, which can be utilized directly and for other data type of the variables, they should be transformed into the numerical value as pre-processing. As for the methods for pre-processing, they should be different for various data types.

After transforming all the variables into numerical value, we can obtain a input set including all the variables $X = \{x_1, x_2, x_3, \dots, x_m\}$.

Through this expression, we can depict the situation using a mathematic method, and the different values of these variables correspond to one instance in the environment. We know there are too many instances in the situation and have different effect on us. We make a decision based on the cognitive perspective to these instances. Therefore, we can consider there exists one super function which brings different effect corresponding to the instances, and this effect can be

evaluated by the numerical value "Y". According to different value of "Y", the making-decision is determined, furthermore, we can classify the problem into two types based on the different meanings of the value of "Y" as follows:

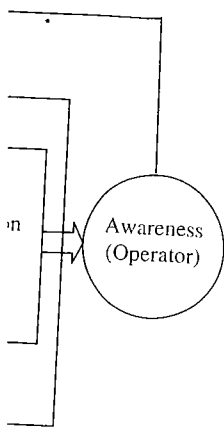
1. Regression Problems: if we need to deal with a forecasting problem such as stock forecasting, rainfall forecasting and so on, the value of "Y" should be continuous, and then they can be regarded as a function regression problem.
2. Classification Problems: if we want to detach the result into several levels and generate awareness and decision based on the different levels, we can consider the problem as the classification problems. The detail idea is shown in Fig. 2.

In this process, we do not rely on many constructs that are frequently used by other SA theorists: comprehension, attention, memory, projection, schemas, and mental models to name just a few. We focus instead on describing and then decomposing the functional, statistical relationship between directly observable variables. In particular, we view all instances of SA to be one of species of judgment judge uncertainty, and use a combination of available judgments analysis techniques as the basis for modeling and measurement.

4. Support Vector Machines Model

The SVMs technique has been introduced for solving pattern recognition problems and function approximations because of their superior performance. In the SVMs, the original dataset is mapped into a

higher separati
space. Let S
present
Let S
where
 $y_i \in \{+$
respecti
the SVM
where d
space x
dimensi
In or
space,
conditi
 y_i
In or
plane v
classes,
problem
subject
separab
to relax
 $y_i(w^T \xi$
 $\xi_i \geq 0$
Accord
inductiv
guarant
 $\min J(w, b, \xi)$
subject
determi
and the
The
using th
introdu
 $\beta_i (i = 1$
function
 $L(w, b, \xi$
 $+ b] - 1$
Acco
optimiz
problem
function
 $w = \sum_{i=1}^l$
where t



Phase 3
Awareness
generation

higher dimensional feature space and an optimal separating hyper-plane is constructed in this feature space. The basic essence of support vector machine is presented as follows:

Let $S = \{(x_1, y_1), (x_2, y_2), \dots, (x_l, y_l)\}$ be a training set, where x_i are m -dimensional attribute vectors, $y_i \in \{+1, -1\}$, $y_i = 1$ and $y_i = -1$ for Classes 1 and 2, respectively. According to Vapnik's original theory, the SVM classifier is:

$$D(x) = w^T \Phi(x) + b. \quad (1)$$

where $\Phi(x)$ is a mapping function which maps input space x into a high-dimensional space, w^T is an m -dimensional vector and b is a scalar.

In order to separate the data linearly in the feature space, the decision function satisfies the following condition:

$$y_i(w^T \Phi(x_i) + b) \geq 1 \quad \text{for } i = 1, \dots, l. \quad (2)$$

In order to determine the optimal separating hyper-plane which has the maximal margin between two classes, we can formulate the following optimization problem:

$$\min_{w,b} J(w,b) = \frac{1}{2} w^T w. \quad (3)$$

subject to (2). If the training data are non-linearly separable, slack variables ξ_i can be introduced into (2) to relax the hard margin constraints as follows:

$$y_i(w^T \Phi(x_i) + b) \geq 1 - \xi_i \quad \text{for } i = 1, \dots, l. \quad (4)$$

$$\xi_i \geq 0 \quad \text{for } i = 1, \dots, l. \quad (5)$$

According to the structural risk minimization inductive principle, the SVMs which minimize the guaranteed risk bound can be represented as follows:

$$\min_{w,b,\xi} J(w,b,\xi) = \frac{1}{2} w^T w + \gamma \sum_{i=1}^l \xi_i. \quad (6)$$

subject to (4) and (5), where γ is a parameter which determines the tradeoff between the maximum margin and the minimum classification error.

The optimization problem of (6) can be solved by using the well-known Lagrange multiplier method. By introducing Lagrange multipliers α_i and β_i ($i = 1, 2, \dots, l$), one can construct the Lagrangian function

$$L(w,b,\xi,\alpha,\beta) = J(w,b,\xi) - \sum_{i=1}^l \alpha_i [y_i(w^T \Phi(x_i) + b) - 1 + \xi_i] - \sum_{i=1}^l \beta_i \xi_i \quad (7)$$

$$+ b] - 1 + \xi_i] - \sum_{i=1}^l \beta_i \xi_i$$

According to the Kuhn-Tucker theorem in optimization theory, the solution of the optimization problem is given by the saddle point of the Lagrangian function and can be shown to have an expansion

$$w = \sum_{i=1}^l \alpha_i y_i \Phi(x_i) \quad (8)$$

where the examples (x_i, y_i) with nonzero coefficients

α_i are called support vectors. Accordingly, the coefficients α_i can be found by solving the following convex quadratic programming problem:

$$\max_{\alpha_i} - \frac{1}{2} \sum_{i=1}^l \sum_{j=1}^l y_i y_j (\Phi(x_i)^T \cdot \Phi(x_j)) \alpha_i \alpha_j + \sum_{i=1}^l \alpha_i \quad (1)$$

subject to

$$\sum_{i=1}^l \alpha_i y_i = 0, \quad i = 1, 2, \dots, l. \quad (2)$$

$$0 \leq \alpha_i \leq \gamma, \quad i = 1, 2, \dots, l. \quad (3)$$

By substituting (8) into (1), the decision boundary function of the classifier can be obtained. Given a new input x , the corresponding value $y(x)$ can be estimated by using (12) and if $y(x) > 0$, classify it to Class 1, on the contrary, it belongs to Class 2.

$$f(x) = \text{sign} \left\{ \sum_{i=1}^l \alpha_i y_i \cdot (\Phi(x_i)^T \cdot \Phi(x) + b) \right\}. \quad (4)$$

5. Conclusion

Situation awareness is commonly used to describe the challenges faced by human operators when interacting with controlled systems or work environments through technological interfaces. The notion of SA has been successfully applied into plenty of practical applications and presents the sharp developing tide. In order to describe the SA control it more expediently, this paper first gives the description of SA a mathematical analysis. It then classifies all the possibilities of SA into classification and regression problems which can be readily resolved by the machine learning tools. A support vector machine model to deal with SA is established based above results. Our future study will include a software development to implement the proposed model.

6. Acknowledgements

The work presented in this paper is supported by Australian Research Council (ARC) under discovery grant DP0211701, and DP0557154.

7. References

- [1] M. J. Adames, U. J. Tenney and R. W. Rew, "Situation awareness and the cognitive managements of complex systems", Human Factors, Vol. 37, No. 1, 1995.
- [2] E. Salas, C. Prince, D. P. Baker and L. Shrestha, "Situation awareness in team performance: implications for measurement and training", Human Factors, Vol. 37, No. 1, pp. 123-136, 1995.

ical value "Y". According to "Y", the making-decision is we can classify the problem the different meanings of the

if we need to deal with a such as stock forecasting, and so on, the value of "Y" us, and then they can be n regression problem.

ms: if we want to detach the vels and generate awareness i the different levels, we can em as the classification dea is shown in Fig. 2.

not rely on many constructs by other SA theorists: i. memory, projection, ls to name just a few. We and then decomposing the ionship between directly particular, we view all species of judgment judge ombination of available iques as the basis for

Machines Model

en introduced for solving blems and function eir superior performance. ataset is mapped into a

- [3] M. R. Endsley, "Measurement of situation awareness in dynamic systems", *Human Factors*, Vol. 37, No. 1, pp. 65-84, 1995a.
- [4] M. R. Endsley, M. W. Smolensky, "Situation awareness in air traffic control: The picture", In: M. W. Smolensky, E. S. Stein (Eds.), *Human Factors in Air Traffic Control*, Academic Press, San Diego, CA, 1998.
- [5] M. R. Endsley, "The role of situation awareness in naturalistic decision making", In: C. E. Zsombok, G. Klein (Eds.), *Naturalistic Decision Making*, LEA, Mahwah, NJ, pp. 269-283, 1997.
- [6] M. R. Endsley, "Toward a theory of situation awareness in dynamic systems", *Human Factors*, Vol. 37, No.1, pp. 32-64, 1995b.
- [7] M. M. Wesler, W. P. Marshak, M. M. Glumm, "Innovative measures of accuracy and situational awareness during landing navigation, the Human Factors and Ergonomics Society 42nd Annual Meeting, 1998.
- [8] C. P. Gibson, A. J. Garrett, "Towards a future cockpit—the prototyping and pilot integration of the mission management aid (MMA), the Situational Awareness in Aerospace Operations, Copenhagen, Denmark, 1990.
- [9] R. M. Taylor, "Situational Awareness Rating Technique (SART): the development of a tool for aircrew systems design", the Situational Awareness in Aerospace Operations, Copenhagen, Denmark, 1990.
- [10] V. N. Vapnik, "An overview of statistical learning theory," *IEEE Trans. Neural Network*, Vol. 10, No. 5, pp. 988-999, 1999.
- [11] T. Joachims, "Making large-scale support vector machine learning practical," in: B. Schölkopf, C. J. C. Burges, A. J. Smola (Eds.), *Advances in Kernel Methods-Support Vector Learning*, MIT Press, Cambridge, MA, 1998, pp. 169-184.
- [12] B. E. Boser, I. M. Guyon, and V. N. Vapnik, "A training algorithm for optimal margin classifiers," in *Proc. 5th Annu. ACM Workshop Comput. Learning Theory*, D. Haussler, Ed., 1992, pp. 144-152.
- [13] V. N. Vapnik. *The Nature of Statistical Learning Theory*. Springer-Verlag, London, UK, 1995.
- [14] V. N. Vapnik. *Statistical Learning Theory*. John Wiley & Sons, 1998.
- [15] E. Brunswik, "Perception and the Representative Design of Psychological Experiments, University of California Press, Berkeley, CA, 1956.

Abstract

The population constantly in the avoid campus informatization analyzed the informatization common structure Based on the re analysis results

Keywords: In Management in

1. Introduction

More than a decade were construct Research Network the first BBS in 1995:

The process They are described paragraphs.

1.1 Hardware

In this period infrastructure can provide network can provide FTP, and so communicate via

1.2 Management period

In this information system Most of them are Client/Server mode a single person,

1.3 Intranet system construction

With the hardware and people need to roles. Teachers based management daily work.

1.4 Central