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# Study on the selection mechanism of opening targeted ship-borne containers carrying dangerous goods

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## STUDY ON THE SELECTION MECHANISM OF OPENING TARGETED SHIP-BORNE CONTAINERS CARRYING DANGEROUS GOODS

By

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# DECLARATION

I certify that all the materials in this research paper that are not my own work have been identified, and that no materials are included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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Date: 1 July 2013

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# ABSTRACT

**TITLE: STUDY ON THE SELECTION MECHANISM OF OPENING TARGETED SHIP-BORNE CONTAINERS CARRYING DANGEROUS GOODS**

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In order to improve the accuracy and efficiency of targeting concealed dangerous goods in sea containers for open-door inspection, people have done a lot of research in this field. Unfortunately, up to now, no one has yet developed a comprehensive targeting system of concealed dangerous goods in sea containers. This study introduced the status of the internal and external research on methods of assessment to target concealed dangerous goods in sea containers, and analyzed the achievements and shortages in this field. Then, this paper established a set of assessment index system of targeting concealed dangerous goods in sea containers on basis of the successful experiences of manpower targeting and achievements of researches from internal and external units. Simultaneously, considering the interaction of each element of assessment, this paper sets up a nonlinear model of assessment of targeting concealed dangerous goods in sea containers with the method of neural network. In the end, by case study, the paper validates the practicality of the established model.

**Key Words：Dangerous goods in sea containers, Open-door inspection, Risk assessment, neural network**

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| | |
|---|---|
| ANN | Artificial Neural Network |
| BP | Back-Propagation |
| CSI | Container Security Initiative |

| | |
|---|---|
| EDI | Electronic Data Interchange |
| IMDG | International Maritime Dangerous Goods |
| IMO | International Maritime Organization |
| MARPOL | Maritime Agreement Regarding Oil Pollution |
| MATLAB | Matrix Laboratory |
| MSA | Maritime Safety Administration |
| MTSL | Maritime Traffic Safety Law |
| OOBA | Out of Box Audit |
| SOLAS | Convention on the Safety of Life at Sea |
| USC | United Shipping Company |

# Chapter 1 Introduction

## 1.1 The background of the research

With the development of world's economy and international trade, shipping volume surges, and the frequency and quantity of ships carrying with hazardous cargo which is combustive, explosive, corrosive, toxic, radioactive, also increase significantly. Since 1966, the international marine container transport has been developing rapidly (Song C.Q., 1984, p.12), and container has become the main transporting pattern of packaged dangerous cargo, but because of the hidden nature of the cargo in container, the concealed and false phenomena of ship carrying dangerous cargo containers also sometimes occur. Such behavior has brought serious threat to ships, personnel safety, and the environmental pollution of water, and even has caused a series of shocking accidents (Chen H.J., 2007, p.15).

The International Maritime Organization provides standards and guidelines for maritime packaging of dangerous cargo through improving and revising the international rules and conventions continuously, and each government also gives their maritime administrated organization the supervision and management right of their domestic transportation of dangerous cargo by legislation inland. Unpacking to inspect container of dangerous cargo is an effective means to implement on-site supervision of dangerous cargo and attack concealed acts of dangerous goods for maritime administrated organizations, and in the unpacking and inspection work of containers of dangerous cargo, the choice of the target containers has always been the core content. How to find out the concealed containers of dangerous cargo from a large number of inbound and outbound containers and how to build a model of unpacking and inspecting the target containers have always been the difficulties for the maritime administrated organizations to solve in supervision and management of ship dangerous cargo containers.

## 1.2 The significance of the research

At present, the maritime administrated organizations can trace out underreporting containers of dangerous cargo through EDI messages. However, for the containers of dangerous cargo which are intentionally concealed by shippers, the maritime administrated organizations can only investigate every manifest by hand with the previous experience and find out possibly concealed containers of dangerous cargo. It is of low efficiency and low accuracy of unpacking container to find concealed containers of dangerous cargo by hand, and it will also cost a lot of manpower and resources. However, the staff of dangerous cargo has accumulated a lot of successful experience in their daily work, and those actions of shippers to conceal dangerous cargo are also exposed out. This paper uses the successful experience of searching concealed and false containers of dangerous goods in manual way for reference, summarizes the various factors to evaluate target containers and finds out the relationships between the various factors, uses evaluation method of neural network which is capable of learning (Chen H.Z., 2003, p.96), establishes the evaluation model of unpacking target containers, and preliminary realizes the automatically filter frame of unpacking and checking out target containers.

The main theoretical significance of this research is, (l) to summarize the domestic and overseas research results of unpacking and checking out containers of dangerous cargo and the experience of unpacking and checking out containers, and establish the evaluation system of target containers in unpacking and checking out containers of dangerous cargo; (2) to take into account that the relationship between evaluated factors of target containers is non-linear relationship which is interacted, this study takes artificial neural network as an evaluation model, the experience of experts of investigating containers of dangerous cargo as a learning sample to establish the evaluation model of target containers to unpack and check out containers of dangerous cargo; (3)to provide scientific reference for the maritime administration to strengthen management of dangerous cargo onboard.

## 1.3 literature review

There are two main methods to confirm the target containers, one is without unpacking the case, making use of γ-rays, X-rays, radiation or radio frequency identification and other techniques to probe containers and find out the target containers; another is making use of risk assessment method to evaluate and determine the target containers.

This study will assess the target containers to find out the target containers with these methods.

### 1.3.1 Current researching situation of foreign risk assessment on the target containers

(1) Risk assessment method of failure mode, effects and criticality analysis

In 2008, Kumar, S. and Verruso, J. presented using failure modes and effects and criticality analysis method to conduct risk assessment of shipping containers entering the United States and finding out high-risk containers as further inspection goals(Kumar S., 2008, p.26). The researching method can find out the risks of containers and the causal relationship between the causes of the risks, and thus systematically identify and assess the danger of high-risk containers. And the factors of risk assessment include, area of manufacturers, shipyards, loading port, destination port, third-party logistics providers and container packing land. Although the risk assessment factors of this study is quite comprehensive, risk assessment methods used in this article do not deeply study the interaction between the factors.

(2) Risk assessment method of scoring

In 2004, Ruth Ellen Wasem introduced the Automated Targeting System of high-risk containers intending to enter the U.S. which were intercepted by the U.S. Customs and Border Security Agency (Ruth E., 2004, p.15). The system introduces the risk assessment of scoring the target containers by assessing, classifying and scoring the standard format bill of lading. The higher the score, the greater the risk, as well as the greater the likelihood to be the target containers. Within the assessment methods of risk, risk assessment factors include the standard format bill of lading, cargo manifest,

intelligence and history. The advantage of scoring risk assessment method is simple and practical, but this assessment method unduly relies on accurate and standard cargo information and cannot assess containers with incomplete information.

(3) Risk prediction

In 2005, Tissington introduced a risk prediction method of imported containers based on data analysis and evaluation (Tissington E., 2005, p.23). The evaluation method mainly classifies various factors of cargo information and scores upon their degree of association with risk, the higher the risk, the higher the score. When 2/3 of the factors get high scores, the container will be defined as high-risk container and must be carried out further checks. When the risk prediction method is used to evaluate in the text, their risk assessment factors include, cargo information, history, and business requirements. The risk prediction method is just to score the assessment factors, and the relationship between the factors is a linear relationship. However, this method does not further analyze mutual relations between the factors of high-risk target containers.

### 1.3.2 Risk assessment on the target containers in China

In recent years, the domestic relevant government bodies also have conducted some studies on the assessment of unpacking and checking the target containers of dangerous cargo containers, and they mainly assess the target containers on dealing with actions of omission of dangerous cargo and concealed actions of shippers.

(1) The assessment methods of target containers in response to underreporting behavior of dangerous cargo

In 2007, Li Jiansheng proposed to collect electronic information of containerized cargo, and filter out the electronic information of dangerous cargo by automatically contrasting the electronic information collected with the names of dangerous cargo listed in "IMDG Code", and then automatically contrast the screened electronic information of dangerous cargo with the electronic declaring information to initially identify the undeclared dangerous cargo (Li J.S., 2007, p.20). The article presents the

imagination of dangerous cargo information construction comprehensively. However, the article only points out how to find out underreporting containers of dangerous cargo by information construction but does not involve the dangerous cargo concealed intentionally by shippers in other ways.

(2) The assessment methods of target containers in response to concealed behavior of shippers

In 2007, Qian Wenlong proposed that the Maritime Bureau should focus on the key ships based on the characteristics of flowing direction of cargo on the route, then ask the agency to provide manifest and determine whether there is concealed phenomenon of dangerous cargo or not through the information in the manifest like the manufacturers and receiving units (Qian W.L., 2007, p.28). The study proposes to establish the key regulatory target and evaluate the target containers from the aspects of manufacturers, consignees and other factors, which provides a new idea to strengthen the supervision of the containers of dangerous cargo. However, the assessing factors of target containers are not rather comprehensive and assessment methods only rest on the manual investigation.

In 2008, Huang Weijin proposed to conduct identification automatically of dangerous cargo upon the cargo names listed in the manifest with the help of screening system software of dangerous cargo to discover and confirm concealed dangerous cargo in time (Huang W.J., 2008, p.47), which provides an idea to determine the target containers of dangerous cargo. However, the article fails to further elaborate how to develop screening system software of dangerous cargo, assessment factors of unpacking and checking out the target containers and how to evaluate the target containers.

In 2008, Lin Yongge pointed out that it should check documents and data of ship's loading fitness and cargo's transporting fitness submitted by shippers (consignee), carriers or agents carefully, and find out concealed containers of dangerous cargo from the differences between reports of loading fitness and transporting fitness (Lin Y.G., 2008, p.48). This paper presents the method to assess target containers by comparing the differences between reports of loading fitness and transporting fitness.

Similarly, in the article, the research on the evaluation factors of the target containers is not very comprehensive, and fails to put forward a comprehensive and detailed assessing method.

## 1.4 Organization of the research

This study proposes a new assessment method to unpack and check the target containers in ship carrying containers of dangerous cargo. The main contents of the study are, the analysis of current researching situation of domestic and foreign assessment of targets containers, the establishment of evaluation system of unpacking and checking the target containers of dangerous cargo, the establishment of assessment mode of target containers based on artificial neural network and the practical proving examples of assessment mode, etc.

The main goals of this research are to complete the analysis of current researching situation of domestic and foreign assessment of targets containers; to establish evaluation system of unpacking and check the target containers in ship carrying containers of dangerous cargo; to establish assessment mode of target containers based on artificial neural network; to solve concealed problems on shipboard containers of dangerous cargo.

This paper uses the research methods of combining theoretical research, computer programming and validating examples. Theoretical research is the basis, and computer programming and examples of validation are verification of theoretical research. Meanwhile, computer programming and validating examples also facilitate the development of theoretical research. In the course of the study, the relationships between them are closely linked and complementary.

The key problems are intended to be solved in this paper include,

(1) The establishment of evaluation system of unpacking and checking the target containers of dangerous cargo;

(2) The establishment of assessment mode of target containers based on BP network;

(3) Solving concealed problems on shipboard containers of dangerous cargo.

Main contents of each chapter in the papers are organized as follows,

Chapter 1 introduces the background and significance of the research, the domestic and foreign research summary of unpacking and checking the target containers of dangerous cargo and also presents the main researching content, researching objectives, researching methods of the paper and the key issues to be solved.

Chapter 2 describes the definitions, classifications and chemical characteristics of dangerous cargo, introduces the concealed behavior of packaging dangerous cargo and its harm, analyzes the reasons of the concealed behavior of packaging dangerous cargo and summarizes the domestic and foreign administrative provisions of packaging dangerous cargo and the main regulatory measures of the domestic and foreign maritime containers of dangerous cargo.

Chapter 3 introduces the process of assessing target containers and source of the assessing factors of target containers, and establishs the evaluation index system of unpacking and checking the target containers of dangerous cargo by researching on the assessing factors of target containers.

Chapter 4 introduces an overview of artificial neural networks and proposes using BP network as assessment model of unpacking and checking the target containers of dangerous cargo with the consideration on the non-linear relationship existing among the assessing factors. In order to improve the learning speed of BP network and avoid local minima problem, this paper improves classical gradient descent method and proposes to use adaptive learning rate momentum gradient descent method as learning algorithm for BP network.

Chapter 5 verifies the practicality of the assessment model based on BP network in unpacking and checking the target containers of dangerous cargo with examples.

# Chapter 2 Current Regulatory and supervision Situation of ship containers of dangerous cargo

## 2.1 Definition, Classification and Chemical Characteristics of Dangerous Cargo

### 2.1.1 Definition of dangerous cargo

Dangerous cargo refers to packaging or bulk items ready for transport which possess the natures of cargo listed in "International Maritime Dangerous Cargo Code," including the characteristics of combustion, explosion, corrosion, toxic, radioactive radiation, and pollution of the environment and other characteristics. Dangerous cargo can be divided into packaged form and bulk forms of transport of dangerous goods.

Dangerous cargo refers to any dangerous cargo loaded in vessels, portable tanks, containers or vehicles (Zhang S.H.,2003, p.1), including empty containers and portable tanks once used for shipping dangerous cargo.

The investigative object of this research is dangerous cargo loaded in containers.

### 2.1.2 Classification of dangerous cargo

In accordance with the dangers presented by dangerous cargo or the main danger, "International Maritime Dangerous Goods Code" divides dangerous cargo into nine categories, and they are, The first category, explosive commodities; the second category, gases; the third category, flammable liquid; the fourth category, flammable solids, easily spontaneous combustion substances and substances which can emit combustible gases in water; the fifth category, oxidizing substances and organic peroxides; the sixth category, toxic substances and infectious substances; the seventh category, radioactive substances; the eighth category, corrosive substances; the ninth category, miscellaneous substances and harmful substances to the environment.

### 2.1.3 The chemical reaction characteristics of dangerous cargo

Dangerous cargo also has chemical reaction characteristics in addition to the characteristics of combustion, explosion, poisoning, radiation, corrosion, and (or) pollution. Chemical reactions may occur when two or more incompatible dangerous cargos contact. It is also possible to happen when some certain dangerous cargo mixed with the surrounding materials or occur itself in a certain environment.

Dangerous cargo has characteristics of combustion, explosion, corrosion, poisoning, radiation, pollution and so on in the process of transport, handling and storage, and most of the characteristics are achieved through chemical reaction.

## 2.2 Concealed behavior, harm and causes of packaged dangerous cargo

It improves operational efficiency and reduces operating costs with dangerous cargo in containers, but because of the concealment of dangerous cargos inside the containers, it is convenient for shippers to conceal dangerous cargo.

### 2.2.1 Concealed behavior of dangerous cargo

In recent years, there were a number of concealed, illegal and misstate events in transport of dangerous cargo dealt with after the specific rectification of shipping dangerous cargos, but concealed behavior of containers carrying dangerous cargos still exists (Xu Y.,2007, p.22). Concealed and false behaviors of dangerous cargos are common names of the phenomena of undeclaration of dangerous cargos should have been declared or the phenomena that declared information is incompatible with the actual situation. Concealed behavior of dangerous cargo mainly occurs in the packaging transport of dangerous cargo in the way of container transport, and individual shipper makes use of the closed characteristics of container transport to illegally conceal dangerous cargo for various reasons. Concealed behavior of ship carrying dangerous cargo not only brings the security risk, but also even causes accidents.

### 2.2.2 Harm of concealed Behavior of dangerous cargos

(1) Harm to people, cargos and ship safety

Since dangerous cargo itself has the characteristics of combustion, explosion, poisoning, corrosion, and pollution, dangerous cargos have special regulations and requirements in the transport, storage, stack and stowage. It will cause fire, explosion, leakage and other accidents in the case of inappropriate protection or improper operation when dangerous cargos are falsely or deceptively reported as ordinary cargos in transport, and cause casualties, poisoning, property damage or environmental pollution, and even cause disastrous consequences.

(2) Harm to the facilities of wharf and cargo security

If the containers of dangerous cargos are falsely or deceptively reported as ordinary cargos in transport, port enterprises cannot predict the risk at all and cannot conduct loading and unloading work and store cargos in accordance with the relevant standards and regulatory requirements of dangerous cargos, and cannot improve safe and reliable berthing conditions for ships carrying dangerous cargos. This increases the risk of port operations and increases the likelihood of accidents.

(3) Interference with normal emergency response and rescue

If dangerous cargos are falsely or deceptively reported as ordinary cargos in transport, in the case of sinks leak, fire, personnel poisoning incidents, it is very difficult to take proper emergency and relief measures in time without knowing the true nature of the cargo.

(4) The influence on the country and the shipping reputation

The existence of concealed, omitted and false behaviors of exporting containers of dangerous cargos makes foreign related authorities feel vigilant and anxious about Chinese exporting container.

### 2.2.3 Reasons for concealed behavior of dangerous cargos

The circulating links of packaging dangerous cargos include, production link, packaging link, storage link, business link, shipping link, transport link, using link and

disposal link, and concealed behavior most likely occur in shipping link,

(1) Lack of knowledge

Shippers' knowledge on transport of dangerous cargos is very poor, and they do not know that the consignments are dangerous cargos, or do not know the special regulations of maritime transport of dangerous cargos, or do not fulfill the obligations to inform the carriers the situation of dangerous cargos, and finally lead to conceal behaviors of dangerous cargos.

(2) Lack of understanding

Shippers do not understand or assess new dangerous cargos enough and mistake dangerous cargos for ordinary cargos to ship. With the rapid development of the world chemical industry, the category of chemical products increases rapidly, especially unlisted dangerous cargos, and relevant provisions of unlisted dangerous cargos cannot be found directly in "International Maritime Dangerous Goods Code", and the lack of understanding on the harm and danger of chemicals leads to mistake dangerous cargos for ordinary cargos.

(3) Benefit motivation

The transporting cost of a container of dangerous cargos is 50% -100% more than the transporting cost of a container of ordinary cargos, or cost even more. And the transporting cost of a refrigerated container of dangerous cargos is 150% -200% more than the transporting cost of a container of ordinary cargos. Thus, driven by high profits, some shippers or agents in shipping link will run the risk to conceal, which is the main reason for concealed and false behaviors of ship carrying containers of dangerous cargos.

(4) Trade restrictions

Because of the characteristics of transport of dangerous cargos, some countries list some dangerous cargos in prohibited or limited range of imports along with the enforcement of "International Ship and Port Facility Security Code," and some shipping companies also list some cargos in the prohibited or limited range. In this case, the two parties may conclude and sign business contracts privately, and in the process of transportation, the shippers evade regulation of authorities by changing the

name of cargos, providing false information or not providing transporting certificate of dangerous goods.

2.3 The domestic and foreign administrative regulations on packaging dangerous cargos

2.3.1 International administrative regulations on packaging dangerous cargos

To ensure transporting safety of shipping dangerous cargos, IMO provides standards and guidelines for maritime packaging dangerous cargos through continuously improving and revising international rules and conventions. The standards and guidelines are mainly,

*(1) SOLAS 1794*

Part A of Chapter Ⅶ in convention provides essential requirements of maritime transport of packaging dangerous cargos and also provides that packaged dangerous cargos can only transport at sea in accordance with *International Maritime Dangerous Goods Code (IMDG Code)*.

*(2) 73/78 MARPOL*

Convention, Annex Ⅲ – regulation of preventing packaging harmfully polluting substances - applicable to all ships carrying packaging dangerous cargos (but not including shipping materials and equipment). The packaging forms within Annex Ⅲ refer to splendid attire forms of harmful substances specified in *IMDG Code*. Harmful substances are those substances identified as marine pollutants in *IMDG Code*, and Convention, Annex Ⅲ primarily carries out through *IMDG Code*.

*(3) IMDG Code*

From January 1, 2004 onwards, *IMDG Code* has become mandatory rules. *IMDG Code* is mandatory international rules of maritime transport of packaging dangerous goods on the basis of and for the implementation of *SOLAS Convention* and *MARPOL73/78*, and *IMDG Code* has become the international guidelines obliged to abide by in the activities of packaging, maritime transport, port operations of dangerous goods.

2.3.2 The domestic administrative regulations on maritime transport of packaging dangerous cargos

In our country, the competent authority carries out supervision and administration on maritime transport of packaging dangerous cargos in accordance with the approval and adopting international conventions and national laws and regulations. Authorized under national law, the Maritime Bureau of the People's Republic of China is the competent authority to implement unified supervision and administration of the traffic safety in the coastal waters, and the units and persons related to the processes of operation, shipping, forwarding and other aspects of packaging dangerous cargos are all in the managing scope of the competent authority. The main domestic laws and regulations on transport of dangerous cargos are,

*(1) Maritime Traffic Safety Law*

*Maritime Traffic Safety Law* is a fundamental law to implement supervision on maritime safety in China. Most of the functions of maritime administration are authorized according to the law. In Chapter VI of the law, it provides that ship facilities storage, handling and transportation of dangerous goods must have safe and reliable equipment and conditions and comply with the domestic relevant regulations of management and transport of dangerous cargos, and also provides to transact declaration formalities in the competent authorities as ships entering and leaving Port.

*(2) Marine Environmental Protection Law*

In *Marine Environmental Protection Law*, Article V formulates supervision and management functions on prevention of marine pollution of national maritime administration, and Chapter VIII provides that the ships carrying hazardous pollution shall enter or leave the port, transit stop or conduct loading and unloading operations with the approval; documentation, packaging, labeling and quantity of hazardous pollution must comply with the regulations.

*(3) Regulations on Administration of Prevention and Control of Pollution to the Marine Environment by Vessels*

*Regulations on Administration of Prevention and Control of Pollution to the Marine*

*Environment by Vessels* provides that the maritime administration can inspect by unpacking the containers in accordance with the regulations of the competent authorities of traffic and transportation of the State Council if hazardous contamination in delivery of ships thought to be declared by the maritime administration but undeclared or the content of declaration does not comply with the actual situation.

*(4) Regulations of the People's Republic of China on Dangerous Chemicals*

*Regulations of the People's Republic of China on Dangerous Chemicals* provides that if shippers ship dangerous chemicals, they should tell carriers' the name, quantity, hazards, emergency measures of transporting dangerous chemicals. It prohibits the shippers to entrain hazardous chemicals within the shipment of ordinary cargos; it prohibits concealing dangerous chemicals as ordinary cargos for consignment.

*(5) Rules on Waterway Transport of Dangerous Goods*

The first part *Packaging Rules on Waterway Transport of Dangerous Goods* is an important technical basis of domestic waterway transport of packaging dangerous cargos.

*(6) Regulations on Ships Carrying Dangerous Goods Supervision and Management*

*Regulations on Ships Carrying Dangerous Goods Supervision and Management* is a special legislation (departmental regulations) in China aiming at ships carrying dangerous Goods. It makes specific provisions on how to declare to the national maritime administrations provided for ships carrying dangerous goods.

## 2.4 The main domestic and foreign regulatory measures on maritime containers of dangerous cargos

### 2.4.1 The main foreign regulatory measures on maritime packaging dangerous cargos

(1) The main regulatory measures on maritime packaging dangerous cargos in Canada

*The Canadian Transport of Dangerous Goods Act* and *Canadian Transport of Dangerous Goods Regulations* are regulations to adjust the Canadian Maritime packaged dangerous cargos. *The Canadian Transport of Dangerous Goods Rules*

directly quotes the main contents of *IMDG Code*, and makes the transport of dangerous goods in Canada and the management of the international transport of dangerous goods matching (Luo D.L., 2002, p.45). The regulation of dangerous cargos of Canadian Government fully embodies the rule of safety and responsibility of "business executives, government surveillance". The Department of Transportation is in charge of transporting safety of national waterway, is responsible for the formulation and revision of laws and regulations on transportation of dangerous cargos and supervises implementation of regulations by companies. The company is responsible for security responsibility of transport of dangerous goods entirely, each port is responsible for auditing import and export declaration of dangerous cargos and checking the transporting situation of dangerous cargos, and denies entry or shipment if dangerous cargos are found not to comply with regulatory requirements (Zhang H.Q., 2001, p.19).

(2) The main regulatory measures on maritime packaging dangerous cargos in the United States

*49 USC - Dangerous Substances Rules* of the United States both matches with the rules related to transport of dangerous goods of International Maritime Organization and also reflects the specific conditions of the United States. After 9.11, the United States passed the port and maritime security law and further strengthened and extended the regulatory functions on dangerous goods containers of the U.S. Customs and Border Protection Bureau. Then, the United States developed a "Container Security Initiative" (referred to as CSI) and "24-hour rule ". CSI upgrades inspection techniques of dangerous goods containers comprehensively from the organization, the examining hardware, software and cooperation mechanism; "24-hour rule " strengthens measures of CSI, which requires the importing manifest information to be submitted to the U.S. Customs 24 hours ahead before by containers prepared to be imported to the United States in a foreign port.

2.4.2 the main regulatory measures on maritime containers of dangerous cargos in China

Our maritime administrations achieve the supervision and management of ships carrying containers of dangerous cargos mainly by means of qualification management for practitioners, credit reporting, on-site supervision and inspection and emergency management.

(1) The qualification management for practitioners

The owners or agents of dangerous cargos, the owners or operators of ports of dangerous cargos and the stations of dangerous cargos containers are required to obtain certification of authorities, and the declaration guard of dangerous cargos, the declaration guard of ship loading dangerous cargos and container inspectors of container shipment of dangerous cargos and other relevant personnel are subject to the training and examination of competent authorities and only work after obtaining the relevant qualification certificates.

(2) Declaration of dangerous goods

①Declaration bill of ship carrying dangerous cargos

In accordance with the requirement of *Ships Carrying Dangerous Goods Trade Supervision and Management Regulations*, if ships carrying dangerous cargos entry and exit port or stopover in the port, *Declaration Bill of Ship Carrying Dangerous Cargos* should be written either directly or through an agent three days before loading (export) or three days prior to the arrival (if the voyage is less than 3 days, it should be written before leaving the port of departure).

② Safety declaration of fitness transport of dangerous cargos

Safety declaration of fitness transport of dangerous cargos is mainly applicable to the export of dangerous cargos. When the shipper consign for export of dangerous cargos, the declaration guard with qualification certificates should transact exporting safety declaration formalities of fitness transport of dangerous cargos to competent authorities three days before loading. Shippers should submit the inspecting certificate of packing containers (issued by the inspection and quarantine departments or the ship

inspection department) as well as "safety declaration bill of fitness transport of dangerous cargos ". There must be "certificate of limited quantity of dangerous cargos" with shipment of dangerous goods of limited quantity; there must be "certificate of limited quantity of radioactive cargos with shipment of radioactive substances; there must be "certificate of additive liquid dangerous goods" with shipment of cargos necessary to be sable or inhibited.

③ Declaration of ships carrying dangerous cargos

The declaration of ships carrying dangerous cargos includes export and import declarations. If ships carrying dangerous cargos entry port or stopover in the port, declaration formalities of dangerous cargos should be conducted to the competent authorities either directly or by an declaration guard of ship at the time arriving at the port; If ships carrying dangerous cargos exit port, declaration formalities of dangerous cargos should be conducted to the competent maritime authority either directly or by a declaration guard of the ship before loading.

(3) On-site supervision and inspection

① Check the packing of dangerous goods

Packing check mainly aims at whether these packing places meet the safety requirements of dangerous goods operations, whether packers work with certificates and whether fire equipment and security measures are implemented and so on. Before packing, packing inspectors and packing unit is responsible for inspection of the containers proposed loading dangerous goods. In the packing process, packing inspectors should guide stevedores to adopt proper and reasonable banding and reinforcement. After that, packing inspector should issue *Container Shipment of Dangerous Cargo Packing Certificate*.

② Unpacking and checking containers

Unpacking and checking containers of dangerous cargos is an effective means to carry out on-site supervision of dangerous goods and to prevent concealed behavior. In China, this method root in the normative documents of Maritime Bureau of the Ministry of Transport, and *Regulations on Administration of Prevention and Control of Pollution to the Marine Environment by Vessels* clearly points out that the maritime

administration can unpacking and checking containers of concealed polluting dangerous cargos. The methods of unpacking and checking containers refer to packing and checking of containers, mainly focus on marks, whether the logos are completed, whether the dangerous goods are consistent with declaration data, whether the packaging of package, packing, stacking, strengthening is in compliance with regulatory requirements, and whether there is concealed falsely behavior.

③ Boarding and checking shipping situation of dangerous cargos containers

Boarding and checking shipping situation of dangerous cargos containers mainly check whether there are fitness loading certificate, the relevant supporting documentation or transport documents; inspect whether the basic information of dangerous cargos is in line with the fact; check whether stowage of dangerous goods is in accordance with the requirements; inspect whether the stowage and isolation between containers meet the requirements.

(4) Emergency Management

The emergency management of maritime administration upon shipping dangerous cargos includes the development of comprehensive emergency rescue plan; equipping with the necessary emergency rescue equipment and various types of protective equipment; establishment of systems of emergency communications network, emergency security, emergency medical assistance and emergency evacuation, and regular exercise (Wang Y.B., 2009, p.15).

## 2.5 Summary

The lack of knowledge and understanding, profit motivation, and other reasons like trade restrictions lead to the concealed behavior of dangerous cargos. The concealed behavior is not only harmful to the safety of crew, cargos and ship itself, but also endangers the safety of terminal facilities of ports and cargos on port, interferes with normal emergency response and rescue, affects countries and shipping reputation and even causes accidents.

# CHAPTER 3 Establishment of assessing Index for unpacking and checking dangerous goods containers

The evaluation process of unpacking and checking target containers of dangerous goods is a process of analyzing the reporting information of containers cargos provided by the shippers and finding out possible concealed containers. The key point in this assessing process is to determine the assessing factors of target containers and to establish evaluation model of target containers. This research confirms the main assessing factors of target containers in unpacking and checking containers of dangerous cargos with the combination of the successful experience of unpacking and checking containers of dangerous cargos on the basis of reference to the domestic and foreign researches of unpacking and checking containers of dangerous cargos.

In this paper, the main assessing factors of target containers are divided into two categories, the first one is the absolute priority factors of assessing target containers. That is to say whenever there is this factor, it is necessary to check the target containers; the other one is necessarily considered risk, namely it is necessary to conduct a comprehensive assessment of these risk factors, and then decide whether to unpack and check target containers, which the main object of study is.

## 3.1 Absolutely prior factors of unpacking and checking target containers

According to the work experience of unpacking and checking containers of dangerous cargos in China, the target container must be unpacked and checked in the following cases.

### 3.1.1 Report information

The containers which are reported to be concealed and false by the masses must be unpacked and checked.

### 3.1.2 Missed reports

Dangerous cargos in containers which are obviously the dangerous cargos stated in *IMDG Code* that should be declared but fail to declare by the comparison of the *IMDG Code* must also be unpacked and checked.

### 3.1.3 Newly detected dangerous cargos

With the rapid development of the world chemical industry, the category of chemical products is growing fast, especially the unlisted dangerous goods which cannot be intuitively found the relevant provisions in *IMDG Code*, so it is more difficult to investigate this type of dangerous cargos. However, a newly detected database of dangerous cargos can be built, and concealed dangerous cargos can be found by comparing the information in the database. For example, the Research Center of Transport of Dangerous Cargos of Dalian regularly publishes the identification results and advisory information of dangerous cargos in "anti-crisis Newsletter", most dangerous cargos of which identified belong to packaging dangerous goods in Class 8 and Class 9 of *IMDG Code*.

## 3.2 Factors to be considered of assessment of unpacking and checking target containers

The assessing factors of unpacking and checking target containers mainly root in daily supervision and management of shipping containers of dangerous cargos of maritime administration and manifest information submitted by ships. By looking up to the relevant literature and referring to the practice of the large domestic ports, the factors to be considered of assessment of unpacking and checking target containers are vessel name, voyage number, bill of lading number, name of goods, shippers, package type, case number, date of coming into port, the manufacturer and the consignee on the manifest, the station receipts of the center and other general information factors; reporting enterprise and its reporting staff, shippers, forwarders, shipping companies, ships, routes and other integrity data factors, whether the real exporting information is

consistent with reporting information of exporting dangerous cargos, whether entering record of cargos is consistent with the information of commodity certificates, whether the information of shipping fitness is consistent with transporting information of cargos and other assessing factors.

By screening and combining with the work experience of unpacking and checking containers, this study considers that the main assessing factors of unpacking and checking target containers of dangerous cargos to be considered are,

### 3.2.1 Routes (loading port)

Due to lax oversight of the port of destination, usually the ships sailing in the routes of Southeast Asia, Africa, South America have more problems on their containers cargo shipped, so they can be seen as key monitoring objects.

### 3.2.2 Ship operators

Ship operators usually have some more regular customers. For example, the relatively stable freight forwarders and shippers also import and export cargos in relatively similar nature, so the shipping companies in which ships were found to conceal can be taken as a key goal of the investigation.

### 3.2.3 Ships

Ships are also taken as the factors of unpacking and checking target containers, which mainly consider the fact that some ships are in poor integrity, as they have been repeatedly found out concealed behaviors of dangerous goods and still donot take corrective measures.

### 3.2.4 Seasonal factors

Pay attention to key period in inspection and care the law of import and export trade. For example, summer is usually the peak season with the demand for foreign pesticide products and in this season, problems are more likely to arise.

### 3.2.5 Name of consignor or consignee

The column of consignor or consignee usually displays the actual consignor or consignee, and sometimes displays the name of the relevant freight forwarders. Usually from the consignor or consignee (goods-producing enterprises), the potential danger of cargos can be seen and then concealed traces of dangerous goods can also be found. For example, plastics and rubber companies usually import and export flammable liquids, resins, vinyl resins and other dangerous goods; spinning and textile printing companies usually import and export stain, cotton, wet spin fiber, corrosion and other dangerous goods; Metallurgy, chemical industry, manufacturing companies will import and export flammable metal (such as zinc oxide, flint), battery, battery and other dangerous goods; Chemical plants usually import and export all kinds of chemical materials, flammable, toxic, corrosive substances; Farming, livestock products companies usually import and export forage, fodder (loose, moist) and other dangerous goods; The pharmaceutical industry usually imports and exports environmental pollution, toxic (such as barium compounds) contamination of dangerous goods.

### 3.2.6 Name of cargos

Name of cargos is usually an important entry point in investigation of concealed dangerous cargos. Since the shipper in consignments must go through the inspection of port sector like customs and quarantine, in general condition, the name of cargos declared by the shipper will not be too different from the actual name. However, at work, there are also the concealed behaviors to declare fireworks as shoe rack. Some key words can be set to further narrow the scope of investigation of concealed dangerous cargos through the names of cargos. The key words include some common names of cargos within previous experience and the names used to cover dangerous cargos by shippers. For example, the declared name containing materials and supplies may often be concealed dangerous goods.

### 3.2.7 Packaging of cargos

The nature of the cargos and packaging has some links, so the packaging can also bring some tips for the investigation of dangerous cargos concealed. If the nature of the goods is inconsistent with the proper packaging，there may be concealed behavior of dangerous goods. Besides, just from the packaging of goods, some dangerous cargos can also be found out. For example, if the packaging form of the cargos is in bottle or bucket, then they may be flammable liquids (such as gasoline, etc.), toxic liquid, corrosive substances or environmentally hazardous liquids; If the packaging form of the cargos is in bags, then they may be oxidizing substances and environmentally hazardous substances; And if the packaging form of the cargos is in containers, then they may be combinations of packaging, and it can be mainly judged by its inner packaging.

### 3.2.8 Freight forwarders and booking people

Freight forwarders and booking people should also be listed as the investigating factors if they had concealed dangerous cargos.

### 3.2.9 Form of cargos

The form of cargos can be seen from the names of cargos, so when the names of cargos is inconsistent with their forms, they may be concealed cargos. The form of cargos can be roughly divided into gas, flowing liquid, gelatinous liquid, powder and bulk solids. Solid material also has natural minerals, metals and substances derived from animals and plants.

Table 3-1 the danger of various forms of cargos (not limited).

| Forms | Flammable | Poisonous | environmental pollution | oxidation material | corrosively | explosive |
|---|---|---|---|---|---|---|
| Gas | ● | ● | | | | ● |
| Liquid | ● | ● | ● | | ● | |

| | | | | | |
|---|---|---|---|---|---|
| Powdered Solids | ● | ● | ● | ● | ○ |
| Bulk Solid | ● | ○ | ○ | ● | ○ |
| Other | ● | | | | |

Table 3-2 evaluation index system of unpacking and checking containers of dangerous cargos

| Destination Layer | first-level index | Second-level index |
|---|---|---|
| Factors to consider in goal container selection | Ship route | Taiwan |
| | | Africa |
| | | Southeast Asia |
| | | South America |
| | | Other |
| | Ship operator | Concealed before |
| | | No conceal |
| | Ships | Concealed before |
| | | No conceal |
| | Season | Summer |
| | | Other |
| | Consignee and consigner name | Plastic rubber company |
| | | Dye house enterprises |
| | | Metallurgical, chemical, manufacturing enterprises |
| | | Chemical plant |
| | | Animal husbandry products enterprises |
| | | Pharmaceutical enterprises |
| | | Other |
| | Cargo name | Cargo name containing materials or supplies |
| | | Cargo name used to conceal |
| | | Key words |
| | | other |
| | Cargo packing | Bottle/Barrel |
| | | Woven bag |
| | | Box |
| | | Other |
| | Shipping agent and Booking party | Concealed before |
| | | No conceal |
| | Cargo forms | Gas |
| | | Liquid |
| | | Colloidal solids |
| | | Powdered Solids |
| | | Bulk Solid |
| | | other |

Table 3-2 lists the evaluation index system of unpacking and checking containers of dangerous cargos, which is professional and operability. The paper below will

evaluate the target containers with this index system.

## 3.3 Summary

Based on the analysis of the factors of risk assessment of target containers, this study suggests that the indicator system of assessment of unpacking and checking target containers of dangerous cargos should include routes (loading port), ship operators, ship, seasonal factors, the name of consignor or consignee, name of cargos, packaging of cargos, freight forwarders and booking party, the forms of cargos.

# Chapter 4 the establishment of evaluation model on target containers based on neural network

The determination of the target containers of unpacking and checking shipping containers of dangerous cargos is complex and has many risk factors. However, the concept of many factors is fuzzy, so it is difficult to describe the factors by using traditional mathematical models. Artificial neural network technology has advantages of achieving parallel processing, distributed storage, robustness, and learning and adaptive ability in addressing the issue of multi-index comprehensive evaluation. Currently, there are some studies on business valuation with the use of artificial neural network technology on enterprise comprehensive strength (Na D.D., 2007, p.12), technological innovation capability, the enterprise sustainable development, the company's future profitability and the corporate credit, and the studies have achieved satisfactory results. This study establishes a comprehensive evaluation model on target containers with use of neural network technology to realize the objective assessment of the target containers of unpacking and checking target containers of dangerous cargos.

## 4.1 Overview of neural network

Artificial neural network is theorized mathematical model of human brain networks and is a machine designed to imitate the human brain works. It can be achieved by electronic or optoelectronic components or simulated in a conventional computer with the software.

Artificial neural network is a hot research field in recent years, and its application has been extended to a number of important areas, including pattern recognition and image processing, process control and optimization, economic forecasting and management, integrated assessment and communication, and it is still continuing to expand (Zhang L.M., 1994, p.21).

### 4.1.1 The development of artificial neural networks

Since the 1990s, the theory of artificial neural network system has entered a stable developing period. The research literature about artificial neural network theory, models and algorithms surges in a large number. The neural network simulation software and utilities chip are continuously introduced. And the application area continues to expand. All these mark the start of the worldwide boom in neural network research.

### 4.1.2 The characteristics of artificial neural networks

Compared with general models and computers, artificial neural network has several outstanding features.

(1) Parallel processing

Parallel processing of ANN refers to the simultaneous operation of different nodes, and the nodes themselves make adjustments in accordance with certain rules. Each node's operation does not make clear contribution to the whole. The inter-node operation rules are the natural results of illogical competition and cooperation, and the final results are only meaningful in the overall macro-level, which is essentially different from generally parallel computing.

(2) Distributed Storage

Each neuron of artificial neural networks is a part of the overall concept and cannot determine the overall status. It is the mutual relationship between these units that can determine the overall state, and the overall content distributes in the mutual relationship between each cell and the state, and an artificial neural network weights includes not only the overall content of the information, also contains the contributions of the whole sample or the entire sample. That is to say, a value is corresponding to the entire combination, and this kind of distributed storage is fundamentally different from other storage methods.

(3) Robustness

In the artificial neural network system, the input of one node is constituted by the

output of several nodes. Each input does not have priority in the competition. The error of one or several nodes do not accumulate up to the operation of other nodes, and the error of one node is also difficult to change competing and cooperating results of the number of nodes. The local changes in low level will not make the information completely lost.

(4) Learning and self-adaption

Another important feature of ANN is a strong learning ability. It can achieve any complex function or mapping to adapt to the changing environment by learning the data with or without a teacher or reinforcement learning. A prominent feature of neural network learning is that in the non-stationary environment (statistical characteristics change with time), just by adjusting the value it can complete the study to track changes of the environment (Zhang L.M., 1994, p.22).

### 4.1.3 The basic structure of artificial neural networks

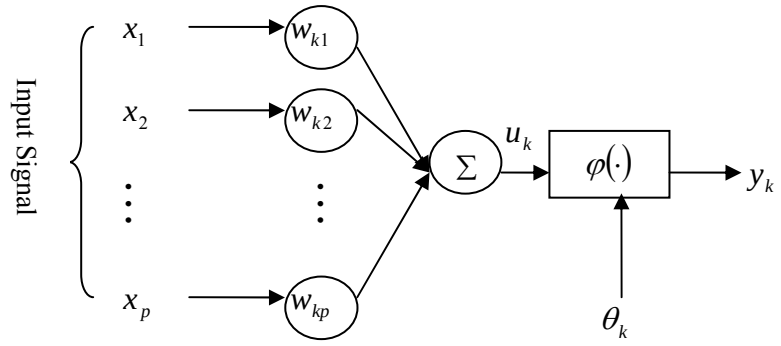
The artificial neuron is simplification and simulation of biological neuron. It simulates biological neuron and can present a nerve cell with a non-linear node of several inputs and one output. Figure 4.1 shows the artificial neuron model as the basic unit of a neuron model, which has three basic elements,

(1) A set of connections (corresponding to a biological neuron synapses). The connection strength is presented by the values on each connection. The right values indicate activation, while the negative representation indicates inhibition.

(2) A summing element. It is used to obtain a weighted sum of the input signals (linear combination).

(3) A non-linear activation function. It needs to make use of the role of non-linear mapping and limit output amplitude of the neuron to a certain range (generally limited to (0,1) or (-1, +1) between).

There is also a threshold value $\theta_k$ .




These above effects can be separately represented in mathematical formula,

$$u_k = \sum_{j=1}^{p} w_{kj} xj\,, \quad v_k = net_k = u_k - \theta_k\,, \quad y_k = \varphi(v_k)$$

In the formula, $x_1, x_2, \cdots, x_p$ are taken as the input signals, $w_{k1}, w_{k2}, \cdots, w_{kp}$ as the weights of neuron $k$, $u_k$ as a linear combing result, $\theta_k$ as the threshold value, $\varphi(\cdot)$ as the activation function and $y_k$ as the output of the neuron $k$.

The neural network model is various. They are description and simulation on different levels of biological nervous system from different angles, and the representative network models contain anti-propagation network, perception, self-organizing map, Hopfield networks, Boltzmann machine, adapt resonance theory. According to the connections of artificial neural network, neural network model can be divided into

(1) Feed forward networks. Each neuron in the network receives the input of former level and output to the next level, in the network there is no feedback. Typically feed forward network can be divided into different layers, the input of $i$ layer only connects to the output of $i-1$, and input and output nodes are connected to the outside, while the other middle layer is called the hidden layer.

(2) Feedback network. All nodes are computing units and also access to the external input and output. If the total number of units is $n$, then each node has one input and one output.

4.2 Structure of BP network

The BP network used in this article is composed of three layers, namely input layer, hidden layer and output layer. Each layer is composed of a plurality of nodes (neurons). The nodes in the same layer do not connect with each other, and the nodes in the two adjacent layers are connected via the connection weights. The output of the former node is the input of the latter node, and the input signal is approached to spread on the progressive layers, and finally gives the output signal through the output layer, Figure 4-2 shows the structure.

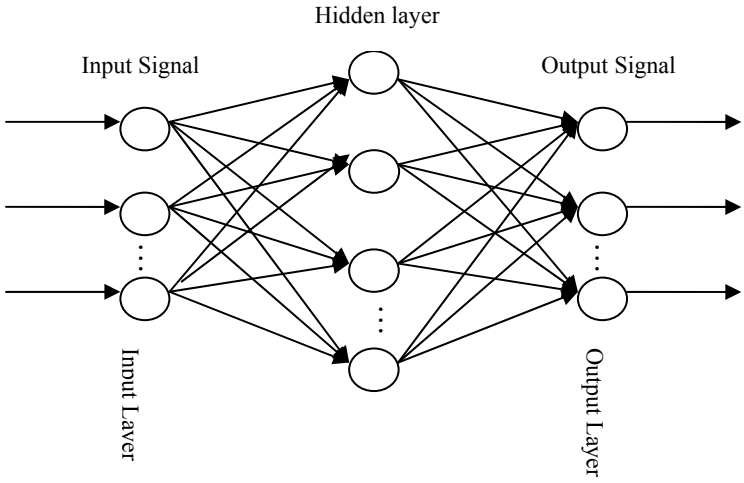



Figure4-2 Three-layer BP network structure

Combining with Figure 4-2, BP network model can be described as,

$$O_k(t) = \sum_{j=1}^{q} \omega_{kj} H_j(t) \qquad (4\text{-}1)$$

$$H_j(t) = g(V_j(t)) \qquad (4\text{-}2)$$

$$V_j(t) = \sum_{i=1}^{p} \omega_{ji} I_i(t) \qquad (4\text{-}3)$$

In the formula, *p, q,* and *r* are the number of neuron of input layer, hidden layer and output layer. $I_i(t)$ is the i-th input of feed forward neural network; $V_j(t)$ is the input sum of the j-th hidden layer neuron; $H_j(t)$ is the output of j-th hidden layer

neuron, set the hidden layer threshold $\theta_j = 0$; $O_k(t)$ is the output of the k-th neuron of output layer, set the output level threshold $\theta_k = 0$; $\omega_{kj}$ represents for the connection weights of the neurons of hidden layer and output layer; $\omega_{ji}$ represents the connection weights of the neurons of input layer and hidden layer; $g(\cdot)$ is a nonlinear varying function, and this paper take Sigmoid function, $g(x) = 1/[1 + \exp(-x)]$ .

4.3 Signal set of input layer

From the above, we can see there are nine major risk factors of target container totally, and each factor is corresponding to a neuron of input layer in BP network, so the signal set of the input layer signal set {input1, input2, input3, input4, input5, input6, input7, input8, input9}={Route, ship operators, ship, seasonal factors, consignor or consignee name, name of goods, packaging of cargos, freight forwarders and booking people, goods form }, among them, each subset of elements is, route = {Taiwan, Africa, Southeast Asia, South America, other}; Ship operators = {have had concealed behavior, have no concealed behavior}; Vessel name = {have had concealed behavior, have no concealed behavior};Seasonal factors = {summer, other}; Consignor or consignee name = {plastics and rubber companies , textile printing and dyeing enterprises, metallurgy, chemical industry, manufacturing companies, chemical, agriculture and animal husbandry, livestock products business, medicine, other}; Name of cargos = {names containing material or supplies, names been used to conceal, keyword, other}; Packaging of cargos = {bottles or barrels, bags, boxes, other}; Freight forwarders and booking people = {have had concealed behavior, have no concealed behavior}; Form of cargos = {gas, flowing liquid, gelatinous liquid, powdered solids, bulk solids, other}.

4.4 Signal set of output layer

In this paper, the output value of neural network is the risk assessment value of target

containers, namely there is only one neuron on the output layer of neural network model. In order to distinguish between the risk levels of different target containers, this paper divides the target containers into four levels according to the order of risk from high to low, and the higher the degree of risk, the higher the priority level in checking, and then the signal set of output layer is {pole high-risk target containers, high-risk target containers, general risk target containers, low-risk target containers}.

4.5 The identification of the number of neurons in hidden layer

In the above, the paper identifies the number of neurons in input layer and output layer, and the number of neurons in the hidden layer can be calculated according to the following formula

$$q = \left| d + \sqrt{p + r} \right| \qquad (4\text{-}4)$$

Wherein, d can be arbitrary integer within interval [0,10].

4.6 Learning algorithm

4.6.1 Gradient descent method

At present, the gradient descent method is commonly used for BP network training (Xu Y., 1999, p.17). The basic idea is, to assign an initial weights for BP neural network, to calculate the output value of the network forward according to the input signal value, and then reverse modify network weights according to the error between the actual output value and the desired output value, and so forth for training to minimize the error (Xu D., 2002, p.19).

Gradient descent algorithm is the application of mathematical optimization methods in artificial neural network. In this method, the weighting is proportional to the amount of correction of errors on the weighted first derivative, and its mathematical formula is expressed as,

$$\Delta\omega = -\eta \frac{\partial E(t)}{\partial \omega}$$

In the formula, $\eta$ is the learning rate; $E(t)$ is objective function, and it is expressed

as follows,

$$E(t)=\frac{1}{2}\sum_{k-1}^{r}\left(y_k(t)-o_k(t)\right)^2$$

In the formula, $y_k(t)$ is the expected output of the network at time t.

Then, various weights correction formula in BP network is,

$$\omega(t+1)=\omega(t)+\Delta\omega(t)=\omega(t)-\eta\frac{\partial E(t)}{\partial\omega}$$

4.6.2 Disadvantages of gradient descent method

Gradient descent method has the advantages of stable working conditions and has strong operability, but it has the following defects,

(l) The problem of local minima problem. Extreme value of networks is corrected step by step along the local direction for improvement, so it often gets actually optimal point.

(2) In order to ensure convergence of the algorithm, the learning rate must be less than an upper limit, which determines the gradient descent method is impossible faster in convergence rate, as point value of the gradient is gradually getting towards zero, the closer to the minimum, the slower the convergence rate of algorithm.

4.6.3 Adaptive learning rate gradient descent momentum

Against the shortcomings of Gradient descent method, there are now several improved learning algorithm (Zheng S.R., 1995, p.44).

(l) Momentum gradient descent algorithm;

(2) Adaptive learning rate gradient descent method;

(3) conjugate gradient method;

(4) Quasi-Newton algorithm;

(5) Liebenberg-Marquardt (LM) optimization method.

During the training of neural network, this paper uses adaptive learning rate momentum gradient descent method as the learning algorithm of BP neural network.

This learning algorithm combines the momentum gradient descent algorithm and adaptive learning rate gradient descent algorithm, and can improve speed and stability of neural network training, and effectively avoid local minima.

Momentum gradient descent method can reduce the sensitivity of error surface and effectively suppress local minima problems arise. In addition, the algorithm updates the weights, with the consideration of successive time gradient direction, so it is possible to improve the stability and convergence speed of learning algorithm. The mathematical expression of momentum gradient descent is,

$$\omega(t+1)=\omega(t)+\eta\left[(1-\alpha)\frac{\partial E(t)}{\partial \omega(t)}+\alpha\frac{\partial E(t-1)}{\partial \omega(t-1)}\right] \qquad (4\text{-}5)$$

In the formula, $\omega(t)$ represents the weight of time *t*; $\frac{\partial E(t)}{\partial \omega(t)}$ represents the gradient of time *t*; $\frac{\partial E(t-1)}{\partial \omega(t-1)}$ represents the gradient of time $(t-1)$; $\eta$ represents the learning rate, $\eta>0$; $\alpha$ is the momentum factor, $0\le\alpha\le 1$.

The Momentum in the algorithm is essentially equivalent to the damping term, and it can reduce the oscillation tendency the learning process and improve convergence.

Learning rate has a great impact on the entire training process. If the learning rate is set too small, the convergence rate is slow, on the contrary, there may be amended overdone, resulting in shock and even diverge. The reasonable change of the learning rate in the training process can avoid the above defects.

Using adaptive learning rate gradient descent method to take feed forward network training will help shorten the learning time. The mathematical expression of the algorithm is,

$$\omega(t+1)=\omega(t)+\eta(t)\frac{\partial E(t)}{\partial \omega(t)} \qquad (4\text{-}6)$$

$$\eta(t)=2^{\lambda}\eta(t-1) \qquad (4\text{-}7)$$

$$\lambda=sign\left[\frac{\partial E(t)}{\partial \omega(t)}\frac{\partial E(t-1)}{\partial \omega(t-1)}\right] \qquad (4\text{-}8)$$

If two consecutive iterative gradients are in the same direction, it indicates that the gradient descent is too slow, then the learning rate is automatically doubled; If two consecutive iterative gradient are in the opposite direction, it indicates that the gradient descent too far, then the learning rate is automatically reduced by half.

According to equation (4-5), (4-6), (4-7), (4-8), the adaptive learning rate momentum gradient descent learning algorithm is,

$$\omega(t+1)=\omega(t)+2^{sign\left[\frac{\partial E(t)\partial E(t-1)}{\partial\omega(t)\partial\omega(t-1)}\right]}\eta(t-1)\left[(1-\alpha)\frac{\partial E(t)}{\partial\omega(t)}+\alpha\frac{\partial E(t-1)}{\partial\omega(t-1)}\right] \quad (4\text{-}9)$$

## 4.7 Summary

This chapter introduces the overview of artificial neural networks, proposes to use BP network as the assessment model of unpacking and checking target containers of dangerous cargos. According to the assessing factors of target containers, the output assessing requirements of target containers and the formula to calculate the number of neurons of hidden layer, this paper determines the evaluation model of unpacking and checking target containers of dangerous cargos based on BP network. Taking into account that using the classical gradient descent method as the learning algorithm of BP network may cause a slow convergence and local minima problems, this paper uses an adaptive learning rate momentum gradient descent method as the learning algorithm for BP network.

# Chapter 5 the validation of evaluation model of target containers based on BP network

In order to illustrate the usefulness of risk assessment models, this study needs to conduct the validation of the evaluation model established, these steps are as follows,

## 5.1 Selection of learning sample

This study uses the method of survey by experts to obtain the unpacking experience of 200 groups of experts in checking dangerous cargos. The questionnaire used is designed according to the actual situation of the investigation of dangerous cargos of Xiamen port. In the process of modeling, the above-mentioned 200 groups of unpacking and checking experience are taken as learning samples of neural network model, and are used to make neural network learn.

## 5.2 Coding of learning samples

In order to facilitate the assessment calculation, it is necessary to conduct custom coding to each element of signal set of input layer, and the weight corresponding to each element is determined by the connection weights of neural network. This article defines,

(1) ship route{ Taiwan，Africa，Southeast Asia，South America，other }={0.11，0.12，0.13，0.14，0.15}；

(2) ship operator{ Concealed　before，No conceal }={0.22，0.24}；

(3) ship{ Concealed　before，No conceal }={0.34，0.36}；

(4) Season{Summer，Other }={0.43，0.46}；

(5) Consignee and consigner name{ Plastic rubber company，Dye house enterprises，Metallurgical/ chemical/ manufacturing enterprises，Chemical plant，Animal husbandry products enterprises，Pharmaceutical enterprises，other }={0.50，0.51，0.52，0.53，0.54，0.55，0.56，0.57，0.58，0.59};

(6) Cargo name{ Cargo name containing materials or supplies，Cargo name used to

conceal，Key words，other }={0.62，0.64，0.66，0.68}；

(7) Cargo packing{ Bottle/Barrel，Woven bag，Box，Other }={0.72，0.74，0.76，0.78}；

(8) Shipping agent and Booking party{ Concealed before，No conceal }={0.82，0.84}；

(9) Cargo forms{ Gas，Liquid，Colloidal solids，Powdered Solids，Bulk Solid，Other }={0.91，0.92，0.93，0.94，0.95，0.96}。

The element coding of output layer defines random value within the range, specific value can be selected by dangerous goods investigators according to degree of risk.

Top risk(0.7,1]；

High risk(0.5,0.7]；

General risk(0.3,0.5]；

Low risk(0,0.3]。

5.3 Setting of training parameter

The main parameters of BP network training are set as follows, training time is 10000; learning rate is 0.011; momentum constant is 0.91; Network performance objective is 0.004; when the training time or the performance objective achieves the requirements, network training will stop (Dong C.H., 2005, p.76).

5.4 Introduction to MATLAB neural network toolbox

MATLAB neural network toolbox mainly consists of variety of functions, and it is the latest neural network toolbox at present. The network models involved are, perception, linear network, BP network, radial basis function networks, self-organizing networks and the feedback network and so on. It almost summarizes new achievements of the existing neural network completely, and it provide users with great convenience. This program of neural network in this paper uses a MATLAB language.

5.5 The achievement of evaluation model validation of target containers of BP network in MATLAB

5.5.1 Main program

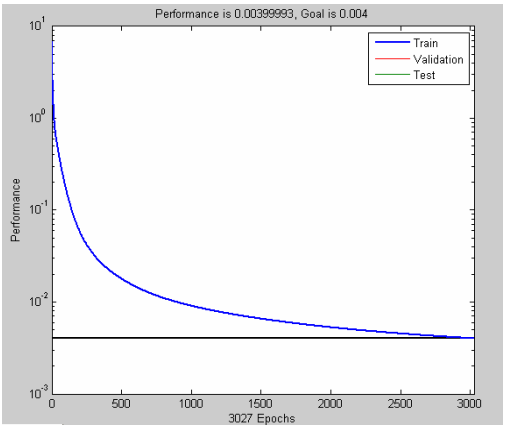
To illustrate the practicality of the assessing model of target containers established, this study takes the unpacking and checking cases of Xiamen Maritime Bureau as the validation samples of the model, and uses MATLAB language to program and calculate assessment model of the neural network, the main program is as follows,

```
close all
clear all
load(‘input1.txt’);
load(‘output1.txt’);
load(‘input2.txt’);
n1=9;
n2=1;
d=5;
n3=floor(sqrt(n1+n2)+d);
n4=200;   %   200 experiences
n5=1;      %   1 example
S1=zeros(n1,n4);
for i=1:n4
      S1(:,i)=input1(   (1+(i-1)*n1): i*n1));
end
S2=output1;
S3=zeros(n1,n5);
for i=1:n5
     S3(:,i)=input2(   (1+(i-1)*n1): i*n1));
end
net=newelm(minmax(S1),[n3,n2],{'tansig' ，'purelin'},'traingdx');
```

```
net.trainParam.epochs=10000;
net.trainParam.lr=0.011;
net.trainParam.mc=0.91;
net.trainParam.goal=4*(1e-3);
[net,tr]=train(net,S1,S2);
Y1=sim(net,S1);
```

### 5.5.2 Results of calculation

Figure 5-1 and Figure 5-2 shows the convergence curve of training error of using gradient descent momentum and adaptive learning rate gradient descent as learning algorithm for BP neural network.



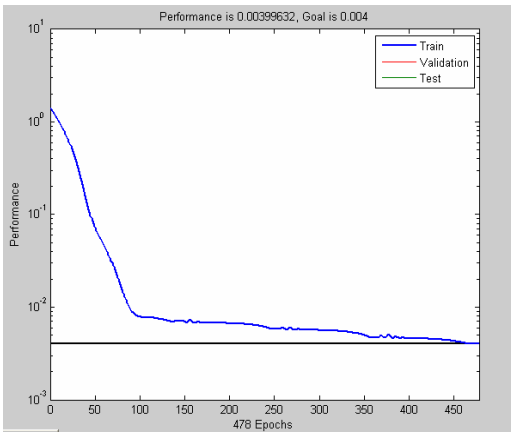




Figure 5-1 convergence curve of Training error by using gradient descent

Figure 5-2 convergence curve of Training error by using adaptive learning rate momentum gradient descent

From the above two figures, it can be seen that using the classical gradient descent method to carry on training of neural networks, when the training times reaches 3027,the network performance objectives can reach for 0.004. However, when adaptive learning rate momentum gradient descent method is used as the learning algorithm of BP neural network, 478 times of training is enough.

### 5.5.3 Example

The following typical cases of unpacking and checking target containers are used to

verify the practicality of the risk assessment model.

Example, the case of concealed dangerous goods of *Xingyun* wheel

(1) ship route：Taiwan；

(2) ship operator：Fujian Xin'an shipping company

(3) ship：*Xingyun*

(4)season：Spring

(5) Consignee and consigner name：consigner：TOPKEY CORPORATION NO.18 20TH ROAD, TAICHUNG INDUSTRIAL PARK；consignee：XIAMEN KEENTECH COMPOSITE TECOLOGY CO. LTD

(6) Cargo name：TENNIS/BIKE/HELMET/MEDICAL RAW MATERIAL

(7) Cargo packing：Package

(8) Shipping agent and Booking party：Fujian Xin'an shipping company's subordinate agency company

(9) Cargo form：Solid

After OOBA (out of box audit)，3 kinds of concealed dangerous cargo had been found：epoxy resin（category 3，UN1866）；colored paint（category 3，UN1263）；benzoyl peroxide（category 5.2，UN3101）；BCS（category 6.1，UN2810）.

It is analyzed based on the above assessment factors,

Fujian Xin'an shipping company mainly runs on the transportation routes of Hong Kong - Xiamen and Xiamen - Taiwan of containers. The historical data show that the company and its affiliated *Xingyun* wheel once had concealed behaviors; From the above consignor or consignee name, it can be known that shipping and receiving company is a general trading company, so there is no concealed behavior; The names of declared cargos contain pharmaceutical raw materials, so it belongs to the cargo name within materials or supplies.

According to the above case information and analysis results, the signal set of input layer of assessment model of unpacking and checking target containers of dangerous cargos based on BP network can be obtained, {routes, ship operators, ship name, seasonal factors, the consignee or consignor name, name of goods, packaging of goods, freight forwarders and booking people, form of cargos} = {0.11, 0.22, 0.34,

0.46, 0.59, 0.62, 0.78, 0.84, 0.95}. If this signal set is input in evaluation model of trained BP neural network, the risk value of the target container can be obtained by calculation. The value is 0.912, so the target container is of extremely high risk, and it is consistent with the results of unpacking and checking containers.

## 5.6 Summary

This study shows that (1) The assessment model of target containers established on BP network technology can effectively achieve the options of target containers, and it provides a new idea for resolving the problem of the determination of target containers of unpacking and checking containers of dangerous cargos; (2) It can effectively improve the learning convergence speed of BP network and avoid local minima problem by using adaptive learning rate momentum gradient descent method as learning algorithm of BP network.

# Chapter 6 Conclusion

## 6.1 Main conclusions

This study introduces the current researching status of domestic and foreign assessment of unpacking and checking target containers of shipping dangerous cargo and analyzes the achievements and shortcomings in assessing target containers of relevant units at home and abroad. Aiming at the shortcomings of the current assessment study of unpacking and checking target containers, the study establishes a set of comprehensive and objective evaluation index system of unpacking and checking target containers of dangerous cargo by using the successful experience of artificial finding concealed and false dangerous cargo for reference and combining with domestic and foreign research results. At the same time, concerning the interaction between the evaluation factors, this study proposes to use BP network to establish the nonlinear evaluation model of target containers. Taking into account that using the classical gradient descent method as learning algorithm of BP network may cause a slow convergence speed and local minima problems, this paper uses the adaptive learning rate momentum gradient descent method as learning algorithm for BP network. Finally, the paper verifies the validity of the assessment model of unpacking and checking target containers of dangerous cargos with actual cases. Studies show that, the assessment model of target containers established on BP neural network technology can effectively achieve options of target containers, and it provides a new idea for resolving the problem of the determination of target containers of unpacking and checking containers of dangerous cargos.

## 6.2 Major innovations

1. On the basis of risk assessment studies of containers of dangerous cargos of relevant department, the paper establishes the evaluation index system of unpacking and checking target containers of dangerous cargos and has a deep study of evaluation

factors of target containers.

2. Concerning the interaction between the evaluation factors, this study proposes using BP network to establish nonlinear evaluation model of target containers. Taking into account that using the classical gradient descent method as learning algorithm of BP network may cause a slow convergence speed and local minima problems, this paper uses the adaptive learning rate momentum gradient descent method as learning algorithm for BP network.

### 6.3 Research Prospects

1. The accuracy of assessment model of unpacking and checking target containers of dangerous cargos has great relationship with the quantity and quality of the experts' experience. To further improve the accuracy of the assessment, it needs more scientific unpacking and checking experience.

2. The assessment method of goal container based on BP network is not only simple and practical, but also has great flexibility. It can create different assessment models by increasing or decreasing neural network input layer neurons' corresponding assessment factors.

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