

# Research on Management System Platform for Multi-Type Wind Turbine Simulation and Training

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## **Abstract**

*After the rapid development of China's wind power industry in the past ten years, many wind turbine types, complex technology and increase of installed capacity lead to the shortage of technology talent. Though domestic universities have established a professional training system for wind power generation, they lack training system on the wind farm site. Therefore, it is very important to build the training management system based on the wind farm. The actual wind farm models, so as to realize the needs of the wind farm owners' actual Technical FAQ, and meet the needs of scientific research talents, but also provide multi-type wind turbine set of modular simulation training management for college students training. This paper discusses the requirement and current status to build an integrated platform from multiple perspectives, and meet the above requirements of feasibility analysis, with the current high-end imported simulation software, the three-dimensional design software, virtual simulation interface software, to set up a*

*On the other hand, information blockade caused by wind power generation technology barriers lead to failure of technology and training to open service, the comprehensive training and simulation comprehensive wind power simulation training management platform, to serve in the wind power industry development needs.*

**Key words:** *wind turbine, simulation, training, management platform*

## **1. Introduction**

The development of large scale wind turbine has gone through several stages [1, 2] of the fixed pitch constant speed constant frequency, variable speed variable pitch doubly fed induction, variable speed variable pitch permanent magnet synchronous wind turbine [3, 4]. The present situation of wind farms is various models of wind turbines, big differentiation of control system specification and function, in view of the wind turbine manufacturers' technical barriers and complex subjects involved, the wind power industry practitioners don't master many core technologies, which limits the training for the talent in the wind power industry and the lack of talent in the industry. The wind farm owner, the last part of the product line, can't find the right channel which is safe in generating electricity, autonomous in maintenance, as the wind turbines beyond the warranty period, rendering the two-sided extreme shortage of talents technology.

Platforms of various wind turbine models has not really established and serve the development of the industry. This paper mainly does a review of research on the development of multi models comprehensive wind power simulation and training management platform.

## **2. Overview of Wind Power Industry**

The earliest development of wind power generation industry in China dates back to the construction of Shandong Rongcheng's first demonstration wind farm in 1986.

After nearly 23 years of efforts, in 2012, the newly installed wind power units in China (excluding Taiwan) were 7872 units, with the installed capacity of 12960MW, drop by 26.5% compared to the same period; the cumulative installed wind power units are 53764 units, installed capacity 75324.2MW, increased by 20.8% compared to the same period. In 2012, Chinese sea newly installed wind power machine were 46 units, with the capacity of 127MW, among which the intertidal installed capacity was 113MW, the sea wind power accounted for 89% of the total installed capacity that was increased. Through investigation, China's new additions in wind capacity were 1610 kilowatts by the end of 2013. With the wind turbines beyond the warranty period, more and more problems of wind turbines appear. Wind farm owners' main work transfers from operation to self repair, but accumulated over the past few years of technical personnel highlights, various complicated models causes technical maintenance team unable to complete the function of the maintenance of the machine factory. With the manufacturers' end of warranty period, and the development of the industry caused by the survival of the fittest, the number of manufactures reduced to about 20, the initial number claimed more than 100. Some manufacturers quitted the market while the leftover problems of their units can not be continually supported in technology.

Many maintenance enterprises begin to repair components like blades, gear box, but it is difficult to set up a team which can systematically solve the problem of unit, the main reason is the shortage of intellectual property and talent team, that is the lack of a comprehensive open multi type wind power simulation and training management system and service platform, including all of the core technology of wind turbine, as well as experts in a comprehensive support team to take charge of the late innovation and service of wind power industry.

The overview of large wind turbine is as followed: domestic manufacturers of the fixed pitch constant speed wind turbine is Golden Wind Science and Technology of 600kW, 750kW, and the main imported type of doubly fed induction generator models in 1990s is 850kW VESTAS and GEMESA Variable-speed doubly-fed wind turbines of VESTAS and GEMESA. And from 2005 double fed wind turbines such as Repower 1500kW, GE, VETAS and 2MW began to enter the China, and the domestic technology manufacturing and independent design of Sinovel 1500kW, 3000kW, 1500kW from Ming Yang, 1500kW from DEC, 2000kW from Shanghai Electric boat in the sea with 2000kW double fed wind turbine, and Gold Wind Technology's 1500kW low speed permanent magnet synchronous wind turbines.

The current wind electric unit is developing to 5MW and above, and the trend is to adapt to the sea wind of large offshore wind development.

Wind turbine impeller has developed from fixed pitch to synchronous hydraulic variable pitch, hydraulic synchronous torque, but also to the DC independent synchronous electric variable pitch, AC independent synchronous electric variable pitch, which change the impeller startup characteristics, feathering safe shutdown protection characteristics, as well as the pitch above rated wind speed limit power function, the maximum amount of power generation and safety.

The generator has developed from squirrel cage induction generator to the doubly fed wound rotor induction generator, permanent magnet synchronous generator. Grid connection has developed from the conduction angle control to control of rotor excitation converter, and then to the full power converter soft cut.

We do not evaluate on the models, so many models has let the owners and maintenance enterprise feel it is difficult to do technical innovation beyond insurance, unable to solve the core technology and technological problems, and therefore it is necessary to have multiple model integrated training management platform in wind power.

### 3. Current Situation of Research on Simulation System

After investigation, the domestic machine manufacturer, Gold Wind Technology, has the national wind power engineering center, with fixed pitch wind turbine training set and direct driven wind turbine of 6MW testing platform. Other large manufacturers such as Shanghai Electric, CSIC, Mingyang Wind Power, Huarui Wind Power, CNR Wind Turbine Co., Ltd. have full power test platform. Component manufacturers such as NGC, Yongji Electric Factory, REnergy Electric Tianjin Ltd, Corona all have test platform for related components [5-10].

The wind farm owners such as the five major power groups have wind power training bases, and the representative training centers are State Power Longyuan Suzhou Longyuan Bailu Wind Power occupation technical training center, Datang new energy wind power training center. Longyuan Bailu Wind Power has Gemasa G58-850kW doubly-fed wind power generation system, Denmark WICON 100kW fixed pitch stall wind turbine, wind turbine components for VESTAS 42-600kW, wind turbine components for Windey 49-750kW, wind turbine components for DEWIND 46-600kW, the latter has Vestas V80 simulation unit and is mainly for the understanding of wind machine principle, grasping the action process, carrying out fault analysis teaching [11-13].

Among the domestic universities and research institutes, Simulation Research and System Security Engineering Center of Beijing University of Chemical Technology has Siemens company interface simulation equipment of E-Wind wind power generator Turbine, the offshore wind turbine generator systems for the scene, has been used several times by "Siemens Cup" National University automation challenge by using virtual reality technology, model simulation of 500kW, grid technology development by asynchronous soft grid to grid connected doubly fed excitation, full power grid connection, also known as grid friendly grid.

All foreign manufactures such as Denmark's VESTAS, American GE, German SIMENSE, also have the test platform for related products.

Germanischer Lloyd (GL) has the Farmer wind farm Wind micro site software, GH Bladed wind turbine load simulation and control strategy verification software, Denmark RISO/DTU developed WASP software includes WASP software and WASP Engineering wind energy resource assessment and wind farm design software such as Wasp software, wind resources in Norway WindSim complete wind electric design tools, the French Meteodyn WT can be applied to complex terrain evaluation software.

In addition, companies specialized in low voltage electrical control system of teaching simulation software, including South Korea electric simulation software V-ELEQ, American National Instruments (NI) Limited launched the Windows based simulation tool of Multisim, applicable to the design simulation work on analog/digital circuit board; the most commonly used control simulation using USA MathWorks company product of commercial mathematic software MATLAB, used for high-level technical computing algorithm development, data visualization, data analysis and numerical computing language and interactive environment. In addition to matrix operations, drawing function / data such as image commonly used functions, MATLAB can also be used to create the user interface and invoke other languages (including C, C++ and FORTRAN) program.

Belgium's LMS Imagine.Lab AMESim, as the hydraulic and pneumatic parameter simulation software, is powerful. Canadian Famic Automation Studio as the hydraulic and pneumatic control simulation tool is more close to the practical application, with many manufacturers, has the simulation interface with large liquid international Rexroth, press manufacturers.

Specially for mechanical design simulation software is numerous, the large-scale general finite element analysis software of USA ANSYS can do structure, fluid, electric field, magnetic field, sound field analysis in one as the wind turbine mechanical load simulation design tool, is also the unit load verification tool. The German Lloyd's (GL) GH Bladed assumes the corresponding wind turbine load simulation and control strategy of verification, forming the corresponding relationship with ANSYS, undertake the work of wind turbine design certification. German SIMPACK AG aims at mechanical / electrical and mechanical system kinematics / multibody dynamics simulation analysis software package Simpack, and American National Renewable Energy Laboratory Open Software FAST (Fatigue Aerodynamics Structures Turbulence) plays a certain role as wind turbine load verification tool software.

The British Romax provides the gearbox design simulation software, the Swiss KISSsoft AG gear design, gear drive system design and the shaft, bearing the professional design software tools, as gear design simulation tool gearbox transmission chain, which belongs to the professional design software. Other control system development platform has the function of programming and simulation. The commonly used control system manufacturers include Denmark MITA, Austria Bachmann, Germany Beckhoff software and hardware platform, as the simulation application.

And the basis of all the wind power source is the fluid field analysis of wind farm, the aerodynamic analysis and design of the blade are regarded as the primary problem, Germany Aerodyn, Holland CTC are blade aerodynamic design company and have the professional commercial software to design the blade aerodynamic airfoil.

The design and simulation of electrical generator is the main unit for wind power production, and should meet the design and production of the converter. Simulation software design software mainly contains the above American ANSYS, American Ansoft HFSS, the former belongs to the parameter level, responsible for the application, the latter is more humanized, is also the world's first commercial 3D electromagnetic field simulation software, which can analyze and simulate arbitrary 3D passive structure of high frequency electromagnetic field, and can directly obtain the results such as characteristic impedance, propagation constant, S parameters and electromagnetic fields, radiation field, antenna pattern.

Although we have numerous functions software and testing platforms, but we lack integrated models of comprehensive simulation training management platform. We also lack practical application software platform which can provide core technology support for wind power technology development, research, training for wind power technology talents on the basis of various mainstream models, which can merge into a many wind turbine models and each primary function components having independent parametric simulation.

#### **4. The Content of the Research**

The key to research on comprehensive management platform of wind turbine simulation is to do research and development on various models of wind power whole machine, research and development experience on control system, the spot debugging experience, and various related discipline knowledge, but also must have experience of using domestic and foreign many types of professional design software, professional simulation software and educational software, years of experience and knowledge reserve and comprehensive technical reserves. Having experienced the wind power industry from the difficult start, medium-term hone, mid blowout development, industry trough, the industry always adhere to its

recovery of industry technical strength to provide a comprehensive platform for industry. Although after investigation, there is not a comprehensive platform parameters that can cover the above three models and is consistent with the actual unit parameters. This paper demonstrates the validity of such a comprehensive simulation platform and urgency professional perspective, the occupation education training, scientific research, industry demand, on the basis of the analysis of market. After the foundation of more than one year's actual study, we provide a solution of modular wind professional simulation platform to wind power market teaching and scientific research and technical renovation for the industry.

### **1) The Necessity and Feasibility of Constructing the Platform**

The installed capacity of wind power in China exceeded 50000 units, ranging from 600kW to 3MW, 5MW, including the fixed pitch constant speed asynchronous generator, pitch variable-speed doubly fed generator, to low speed PM generator, high-speed permanent magnet generator. Considering such degree even models, a core technology platform is needed in an emergency to ensure work on the stock market, train personnel and technology innovation. And all the machine manufacturers, parts manufacturers, the control system software providers, software providers, do not have the ability to provide open and integrated platform. Due to technical barriers, the owners also have no resources and manpower to complete the above platform. The theory of wind power generation is using the wind to blow blades, which will drive the impeller to rotate. Then it transforms the wind energy into mechanical energy, that's the principle of wind power generation. With the consideration of current wind power generation technology, a gentle wind (about 2 m/s) can drive the wind generator.

At present, the wind turbine use the horizontal axis wind and the wind turbine impeller connected with the gear box machinery by a long shaft, power transmission goes through gear box and the high speed shaft and universal flexible coupling connected to torque to the drive shaft through the shaft generator. The shaft should be good at damping and vibration absorbing, absorbing right amount of the axial and radial angle deviation, and the mechanism of coupling preventing overload. The above field axis wind turbine can be divided into fixed pitch constant speed induction generator and variable pitch variable-speed doubly fed induction generator.

Another wind turbine model is permanent magnet wind turbine with all impellers directly connected to the generator without gear box to make the transmission chain more compact.

In view of the above analysis, the variable speed unit all possesses variable pitch system except for the fixed pitch wind turbine. And the system not only realize a quick start and a fast feathering shutdown protection, but also collecting the paddle when out of rated speed, ensure the input energy does not exceed the limit value of transmission chain, prevent wind motor group of super hair caused by mechanical and electrical injury.

Considering the above analysis, constructing an open wind power management platform should be imperative.

### **2) The Framework of Simulation Training Management Platform**

#### **① Modeling of Impeller**

The modeling of impeller can be divided into fixed blade stall type and pitch blade type. The modeling can be operated through some detailed parameters, including cascades data and mass distribution of real blade [14-18].

## ② Modeling of Displaced System

The platform of fixed pitch constant speed unit is not described in this essay. The basic function of torque and pitch control has two core points according to wind power system characters. One of them is to protect the security of feathering downtime in a strong wind circumstance, and the other one is to ensure the impeller input mechanical energy less than transmission chain limit above the rated wind speed. So it can timely adjust the pitch angle with the change of wind speed, meanwhile it can quickly transfer from mild wind standby mode to the shift into grid mode through overcoming inertia in the fastest speed. By controlling the absorbing wind energy the system can not only get the most qualified wind energy also it can weaken load impact of wind turbine generator in wind crossfade.

In the process of wind turbine generator change from stand by to grid connection, the pitch control system has to connect the variable flow system for realizing grid-connected in zero power. It can also coordinate master control system and exchanger in the trans process of LVRT low voltage, and it can help the wind turbine generator not generate electricity on the net in the process [19] of low voltage transients. It can avoid electrical shock because large area wind turbines take off the net in voltage transient, aiming at improving the generating efficiency and power quality of wind turbine generator.

The feature of braking device is aerodynamic brake braking alone by the variable pitch control, and the blade can get full brake function. Even if a blade brake failure, the other two blades also can end the safety braking process, improved the security of the whole system. Brake system is also equipped with backup power for recovering the blade rapidly and accurately when fault or maintenance time.

## ③ Modeling of Transmission Chain

For long axis wind turbine model, coupled with increasing gear box, basically adopts the double center of mass or three center of mass. But they can't complete performance dynamic characteristic of the transmission chain, how close to real transmission chain, which is hard to be solved at present. The main reason is not to get all the design parameters.

## ④ Modeling of Electric Generator

Asynchronous generator and the doubly-fed generator modeling can have reference data, but a direct-drive generator at low speed and high speed permanent magnet generator model need more data to support to complete the real model.

## ⑤ Modeling of Converter

Asynchronous generator soft grid controller modeling has any references, and doubly-fed converter model also has carried on the quite a lot of research. But full power converter modeling still needs some time.

## ⑥ Modeling of Master Control System

Main control system is the brain of a coordinate all wind turbines, and it can conduct the process fault to ensure the fate of the unit as it is applied to coordinate the whole technical process.

## ⑦ Human-Computer Interface and Background Data

They can complete real-time database, interpersonal interaction and analysis of data aggregation, containing a lot of software interface, which can be used as the data center of simulation integrated management system. More than three kinds of

software are used to build a data processing system and complete the platform construction in this essay.

## 5. The Choice of System Simulation Software

In order to complete the model simulation system design more, it is necessary to be integrated into a unified comprehensive platform with the least amount of software. In wind turbine design, the choice of blade airfoil design is the primary task [20-22], and the stall type blade is only used to set the pitch constant speed unit. The design of the variable pitch blades selection is used to the current mass installed variable-speed double-fed generator and the permanent magnet synchronous generator.

This paper uses the GH Bladed as virtual machine simulation software, which can import all blade airfoil data and input parameters, including basic parameters of the unit, transmission chain, generators, tower and the wind, etc. As parts of virtual machine parameters, they can provide authentication and the control strategy of the load analysis prototype.

GH Bladed model begins with fixed pitch constant speed unit. Only through the generator load adjustment for wind velocity fluctuations impact load transmission chain, and transmission chain damage cannot be effectively controlled and reduced. Upgraded version with variable speed doubly-fed wind power generator adopts the technology of variable pitch and variable frequency excitation technique and eliminates the above fixed pitch generator technical shortcomings. In this way wind turbines can live in a big wind speed interval, transient by reducing wind speed of wind turbine transmission chain large static or dynamic impact [2], and it can extend the fatigue life of the unit. Permanent magnet synchronous generator with full power converter can realize soft interconnection of power grid friendly and eliminates the doubly-fed excitation converter technology defects such as complicated control technology. If low-speed permanent magnet generator without growth is used, the point of failure will reduce more links.

GH Bladed interface as Figure 1, include more parameters about wind turbine, support library operation based on Matlab, and it has a PI controller, internal with external DLL interface specification and interface or EXE file. Especially in the version 3.82 above has the function of hardware to test functional procedure in the factory and connect to the control system hardware ark. As a simulation platform for the unit load changes caused by wind turbines control strategy to provide validation data, and it has the characteristics of the working condition of each corresponding analysis and post-processing tools to have a output prediction, etc., And MATLAB software has a more detailed simulation function, it also has a chain of wind power machinery, control system, inverter, variable pitch system, which can do more detailed modeling work. Although there are some real problems in simulation, with each link simulation library can easily realize simulation of high-end research and development.

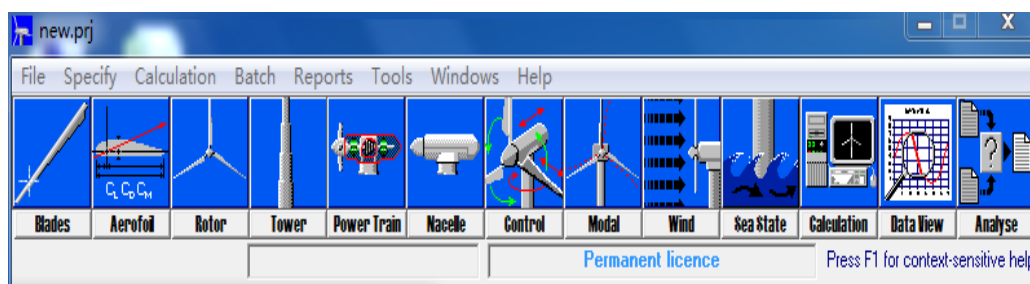


Figure 1. GH Bladed Interface

Beckhoff TWINCAT embedded platform with advanced language interface can fuse the Microsoft Visual Studio development platform. After successful implementation in Matlab simulation control system software C code can be exported, So it can be inputted directly into the controller as the control system application and have better means to optimize function of optimization control system.

SCADA system has real-time database and other units such as Famic Canada Automation Studio hydraulic, pneumatic, control simulation software. According to the 3D design software tools to complete 3d entity, such as the United States SolidWorks link Sweden's virtual reality software EON Studio or the MSC Adams multi-body dynamics software, it can achieve and integrate analysis data of wind farms. It is viable to compose a set of instantiation of wind power integrated interactive simulation system.

## 6. The Design of Multi-Type Wind Generator Integrated Simulation System

In view of the above requirements, multi-type wind generator integrated simulation system should be built in the laboratory, and BACHMANN, TWINCAT, L40, X200 various control system of PLC, electric variable pitch system experimental platform and comprehensive simulation training system will be adopted. A set of ac servo drive permanent magnet generator, the doubly-fed generator, asynchronous motor in combination with mechanical assembly will be communicated between PC and drive.

### 6.1. ADS Data Interaction between GH BLADED and TWINCAT PLC [23]-[26].

In the structure of the software system, the communication between GH Bladed DLL files and TWINCAT soft PLC software is the core of control system software simulation testing. DLL programming use ADS communication protocol of high-level language support, the DLL as one site to TWINCAT on the ADS channel, at the same time the TWINCAT soft PLC act real time database of SCADA communication, TwinCAT system architecture as shown in Figure 2 based on ADS:

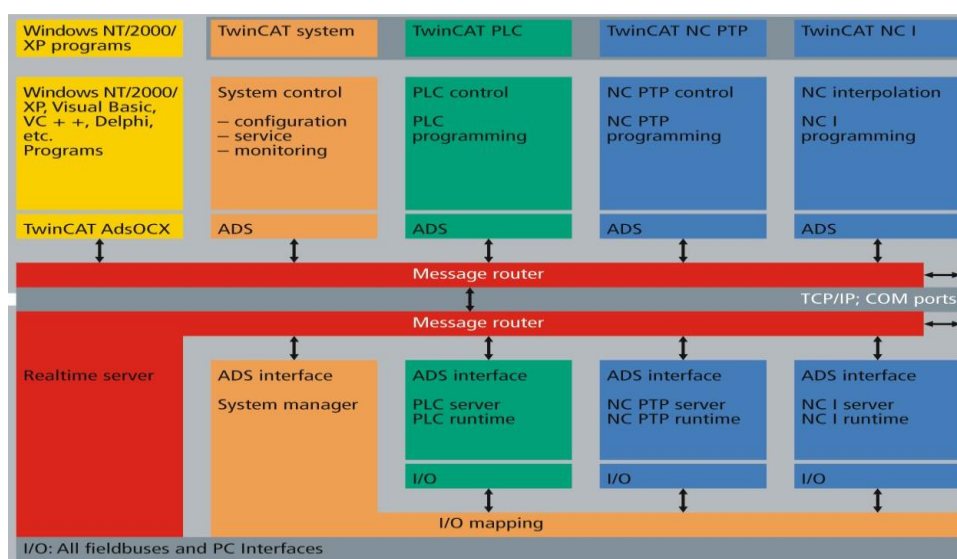


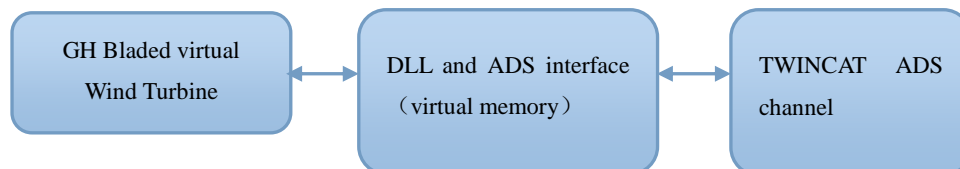
Figure 2. TWINCAT System Frame Basis ADS



## 6.2. The ADS Protocol in the Application Layer Protocol of Network Communication TCP/IP, Communication More Convenient. [27]-[30]

Each TwinCAT ADS devices have different AdsAmsNetId and AdsPort (port number), to distinguish. AdsAmsNetId is an extension to the TCP/IP address, is the TwinCAT Message Router, exist in each TwinCAT PC or BeckhoffCX, BX, BC series controller.

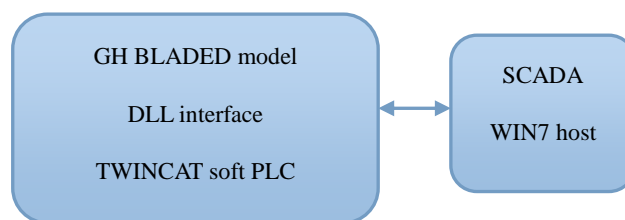
Between TWINCAT soft PLC software and DLL, the whole interaction process as shown in Figure 3.



**Figure 3. Interaction Flow between GH Bladed DLL and TWINCAT**

## 6.3. PC Virtual Machine

This paper uses the VMWARE virtual machine to install the WIN XP system as GH BLADED and TWINCAT PLC operating platform, WIN7 X32 as host running SCADA system. This is conducive to the GH Bladed virtual machine individually adjusted parameters, does not affect the task scheduling and data SCADA system host analysis, system frame as shown in Figure 4.



**Figure 4. Frame of System Platform**

Single virtual wind turbine operation implementation of virtual machine system, the implementation of TCP protocol and the host communication, ADS communication is under TWINCAT, another programming act communication between TWINCAT and SCADA by ADS, the operation scheduling of above two features of the software, the successful operation to each simulation.

## 7. Conclusion

With this paper, the multi-type wind generator integrated simulation system platform can act easily, and adding the energy management SCADA platform with real-time database, with more communication software communication, show the relevant models fault and operation parameters. Compared the unit with remote SCADA data, the implementation of multi-type wind generator integrated simulation system platform with a function such as wind power technology research, training, technical reform just around the corner.

## Acknowledgment

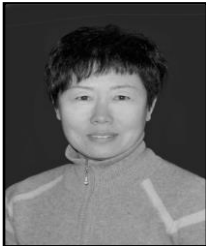
The authors gratefully acknowledge the financial support by the Department of Education of Liaoning Province under Grant L2012461.

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