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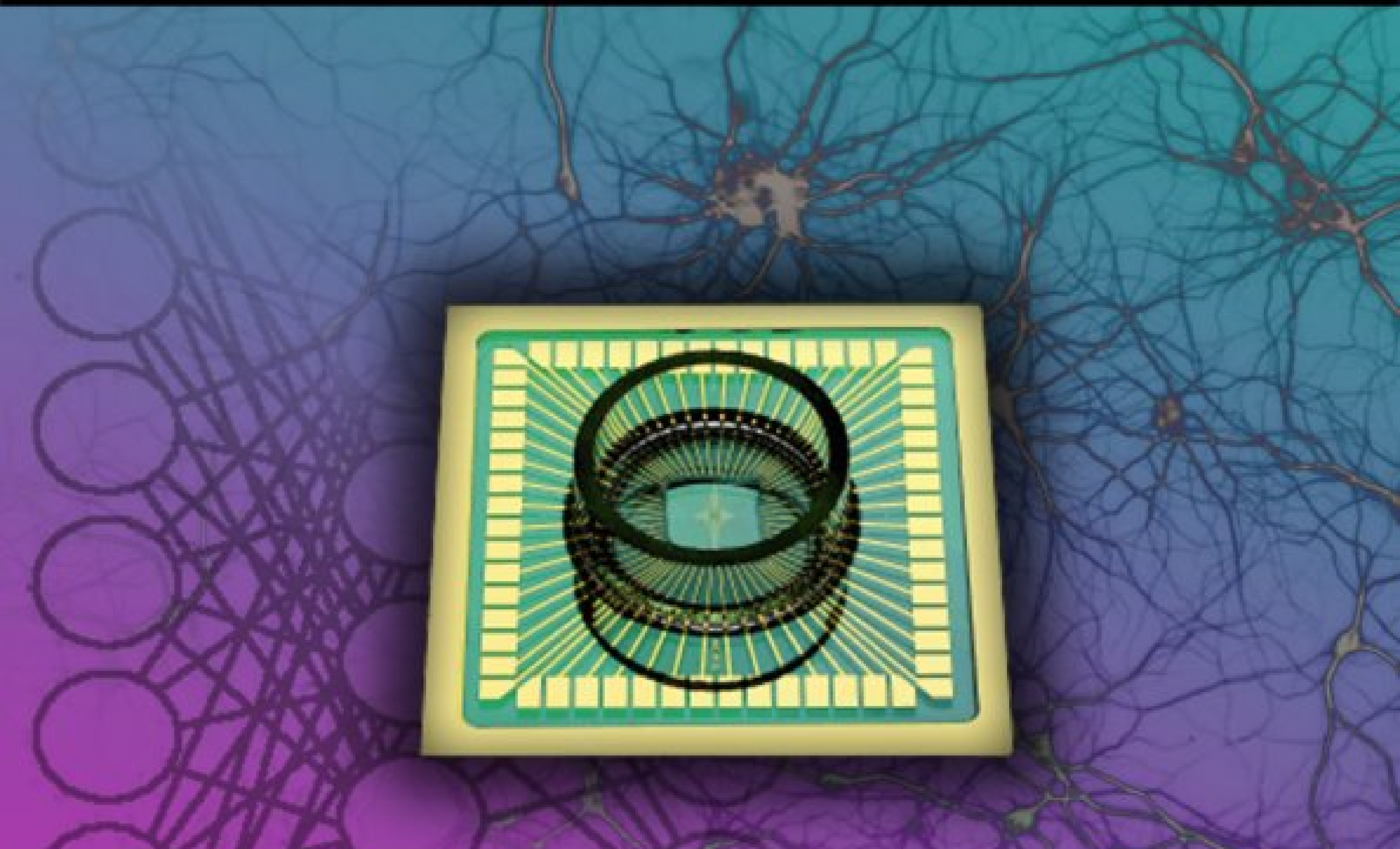

Soft Sensors and Artificial Neural Networks

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The Seventh International Conference on Networking and Services

ICNS 2011

May 22-27, 2011 - Venice, Italy

Important deadlines:

Submission (full paper)	January 10, 2011
Notification	February 20, 2011
Registration	March 5, 2011
Camera ready	March 20, 2011

http://www.iaria.org/conferences2011/ICNS11.html

Tracks:

- ENCOT: Emerging Network Communications and Technologies
- COMAN: Network Control and Management
- SERVI: Multi-technology service deployment and assurance
- NGNUS: Next Generation Networks and Ubiquitous Services
- MPQSI: Multi Provider QoS/SLA Internetworking
- GRIDNS: Grid Networks and Services
- EDNA: Emergency Services and Disaster Recovery of Networks and Applications
- IPv6DFI: Deploying the Future Infrastructure
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- GOBS: GRID over Optical Burst Switching Networks

The Third International Conference on Bioinformatics, Biocomputational Systems and Biotechnologies

BIOTECHNO 2011

May 22-27, 2011 - Venice, Italy

Tracks:

A. Bioinformatics, chemoinformatics, neuroinformatics and applications

- Bioinformatics
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- Chemoinformatics
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B. Computational systems

- Bio-ontologies and semantics
- Biocomputing
- Genetics
- Molecular and Cellular Biology
- Microbiology

C. Biotechnologies and biomanufacturing

- Fundamentals in biotechnologies
- Biodevices
- Biomedical technologies
- Biological technologies
- Biomanufacturing

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http://www.iaria.org/conferences2011/BIOTECHNO11.html

The Sixth International Conference on Systems

ICONS 2011

January 23-28, 2011 - St. Maarten, The Netherlands Antilles

Important deadlines:

Submission (full paper)	September 25, 2010
Notification	October 20, 2010
Registration	November 5, 2010
Camera ready	November 5, 2010

http://www.iaria.org/conferences2011/ICONS11.html

Tracks:

- Systems' theory and practice
- System engineering
- System instrumentation
- Embedded systems and systems-on-the-chip
- Target-oriented systems [emulation, simulation, prediction, etc.]
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- Advanced systems [expert, tutoring, self-adapting, interactive, etc.]
- Application-oriented systems [content, eHealth, radar, financial, vehicular, etc.]
- Safety in industrial systems
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Design of Artificial Neural Network-Based pH Estimator

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Abstract: Taking into consideration the cost, size and drawbacks might be found with real hardware instrument for measuring pH values such that the complications of the wiring, installing, calibrating and troubleshooting the system, would make a person look for a cheaper, accurate, and alternative choice to perform the measuring operation, Where's hereby, a feedforward artificial neural network-based pH estimator has to be proposed. The proposed estimator has been designed with multi- layer perceptrons. One input which is a measured base stream and two outputs represent pH values at strong base and strong/weak acids for a titration process. The created data base has been obtained with consideration of temperature variation. The final numerical results ensure the effectiveness and robustness of the design neural network-based pH estimator. *Copyright © 2010 IFSA.*

Keywords: pH electrode, Titration process, Neural network and Training algorithm.

1. Introduction

pH plants had always drawn the attention of the chemical engineers due to its importance in different fields: from the medicine and the effect of pH on the enzymes and blood, to industry which is concerned with manufacturing of textile dyes, and bleach products, to the environmental issues concerned with treating waste water to be environmentally safe and the acidic rains researches, and finally in the army to have a safe monitoring of the pH in the nuclear reactors and the resulted materials [1].

The pH unit measures the degree of acidity or basicity of a solution. And To be more exact it is the measurement of the Hydrogen ion concentration, [H+]. The value of the pH of any solution is between

0-14, where the values below 7 pH exhibit acidic properties, while values above 7 pH exhibit basic properties, and 7 is neither acidic nor basic, therefore it is called "neutral".

The pH of a solution is an important propriety that a chemical engineer depends on to judge the solution, which is the basic procedure towards the analysis and treating the solution, especially while the pH could express a sensitive and dangerous effect of this solution on the surrounding environment.

This work aims to save the trouble of providing a big financial support and a large skillful labor crew that are needed to operate the system, by simply replacing all the complementary devices of measuring and compensating with a software that is programmed with enough insight and understanding of the system, and is able to produce a signal that represent the required estimation after performing the needed compensation and correction of the factors, this done with the design of a neural network-inversely thermo-chemical model to produce an output that simply expresses the estimated value of pH with respect to different input parameters (mass concentration and base flow rate) taking into account temperature variation.

2. Conventional Methods for Evaluation of pH

Before explaining, briefly, the conventional pH evaluation methods and how do they work on sensing and measuring the pH, it is essential to explain the measuring mechanism of pH in solutions.

A pH measurement loop is made up of three components, the pH sensor, which includes a measuring electrode, a reference electrode, and a temperature sensor; a preamplifier; and an analyzer or transmitter. A pH measurement loop is essentially a battery where the positive terminal is the measuring electrode and the negative terminal is the reference electrode. The measuring electrode, which is sensitive to the hydrogen ion, develops a potential (voltage) directly related to the hydrogen ion concentration of the solution. The reference electrode provides a stable potential against which the measuring electrode can be compared.

2.1. pH Meter

When immersed in the solution, the reference electrode potential does not change with the changing hydrogen ion concentration. A solution in the reference electrode also makes contact with the sample solution and the measuring electrode through a junction, completing the circuit. Output of the measuring electrode changes with temperature (even though the process remains at a constant pH) [1], so a temperature sensor is necessary to correct for this change in output. This is done in the analyzer or transmitter software. Fig. 1 shows a simplified typical pH sensor.

The pH sensor components are usually combined into one device called a combination pH electrode. The measuring electrode is usually glass and quite fragile, as seen in Fig. 2. Note that the thin, lithium doped glass membrane across which the pH voltage is generated.

Recent developments have replaced the glass with more durable solid-state sensors. The preamplifier is a signal-conditioning device. It takes the high-impedance pH electrode signal and changes it into low impedance signal which the analyzer or transmitter can accept. The preamplifier also strengthens and stabilizes the signal, making it less susceptible to electrical noise.

The sensor's electrical signal is then displayed. This is commonly done in a 120/240 V ac-powered analyzer or in a 24 V dc loop-powered transmitter.

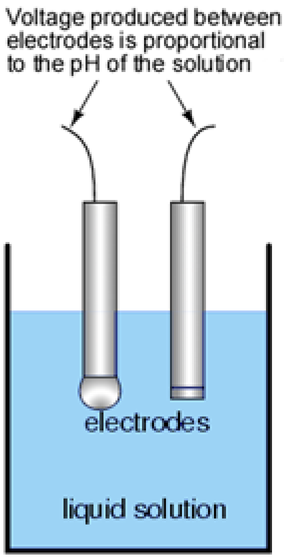

Fig. 1. Shows a simplified pH meter.

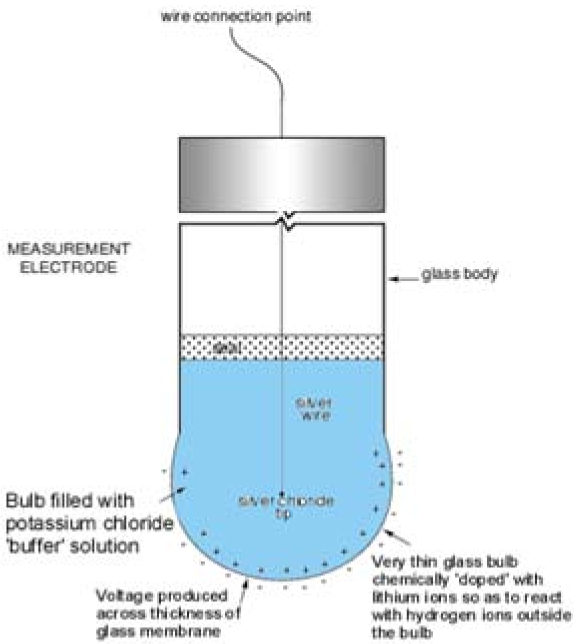

Fig. 2. Measuring Electrode- glassed body.

Additionally, the analyzer or transmitter has a man machine interface for calibrating the sensor and configuring outputs and alarms, if pH control is being done.

Keep in mind, application requirements should be carefully considered when choosing a pH electrode. Accurate pH measurement and the resulting precise control that it can allow, can go a long way toward process optimization and result in increased product quality and consistency. Accurate, stable pH measurement also controls and often lowers chemical usage, minimizing system maintenance and expense.

2.2. pH Measurement

While pH can be measured by color changes in certain chemical powders, continuous process monitoring and control of pH requires a more sophisticated approach. The most common approach is the use of a specially-prepared electrode designed to allow hydrogen ions in the solution to migrate through a selective barrier, producing a measurable potential (voltage) difference proportional to the solution's pH.

What is important to understand is that these two electrodes generate a voltage directly proportional to the pH of the solution. At a pH of 7 (neutral), the electrodes will produce 0 volts between them. At a low pH (acid) a voltage will be developed of one polarity, and at a high pH (caustic) a voltage will be developed of the opposite polarity.

An unfortunate design constraint of pH electrodes is that one of them (called the measurement electrode) must be constructed of special glass to create the ion-selective barrier needed to screen out hydrogen ions from all the other ions floating around in the solution. This glass is chemically doped with lithium ions, which is what makes it react electrochemically to hydrogen ions. Since glass is an extremely good insulator. This presents a major problem if our intent is to measure voltage between the two electrodes. The circuit path from one electrode contact, through the glass barrier, through the solution, to the other electrode, and back through the other electrode's contact, is one of extremely high resistance.

The other electrode (called the reference electrode) is made from a chemical solution of neutral (7) pH buffer solution (usually potassium chloride) allowed to exchange ions with the process solution through a porous separator, forming a relatively low resistance connection to the test liquid. At first, it could be thought of just dipping a metal wire into the solution to get an electrical connection to the liquid. But this method won't be useful is because metals tend to be highly reactive in ionic solutions and can produce a significant voltage across the interface of metal to-liquid contact. The use of a wet chemical interface with the measured solution is necessary to avoid creating such a voltage, which of course would be falsely interpreted by any measuring device as being indicative of pH [1, 2].

2.3. Troubles Found with pH Metering and Conventional Solutions

Many troubles of pH measurement could be faced in practice. For example, electrical interference, relay hunting, in-Line calibration, current transmission 4-20 mA, pH measurement in liquids with hydrofluoric acid, ORP measurements, prevention of chemical wastage and manual temperature compensation [1].

3. Non-Conventional Proposed NN-Based Evaluation Method

With respect to the problem geometry that has been discussed in previous sections, it could be concluded the importance to find an alternative solution for evaluation of pH values instead of pH probe. The proposed evaluation method, as an alternative for conventional methods, should have an adaptative feature. That is means, to estimate pH with respect to the measurement of the base stream and with taking into account any temperature variations without needs of temperature probe (another hardware compensation). However, there are many instances where a temperature probe is not being used. This typically would be when there is no large variation in temperature of the process [2].

So, the physical problem which we deal with is non linear, that is why a non linear feedforward multi-layer neural network MLP-NN has been chosen and validated, numerically, with MatLab (M-files) as will seen in the next sections.

3.1. Structure of the Proposed MLP-NNE

The structure of an artificial multi-layer neural network pH estimator (MLP-NNE), seen in Fig. 3.

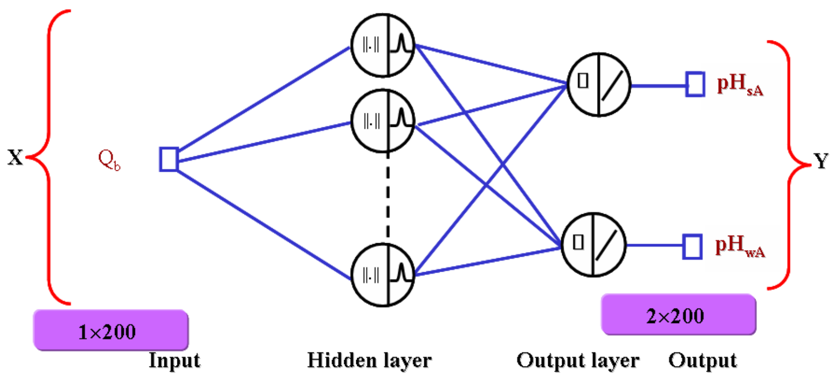

Fig. 3. Structure of the proposed MLP-NNE.

Fig. 3 shows the internal structure of the proposed NN. In Fig. 3, the NN has 1 input (Q_b) represents the measured base stream and 2 outputs pH_{sA} and pH_{wA}. Where pH_{sA} and pH_{wA} are the pH at strong and weak acid, respectively.

The structure used in this work for this type of application constitutes of one hidden layer with a hyperbolic tangent activation function and output layer with linear function as shown above.

3.2. The Training Algorithm

The training algorithm used in this work is the conventional backpropogation algorithm.

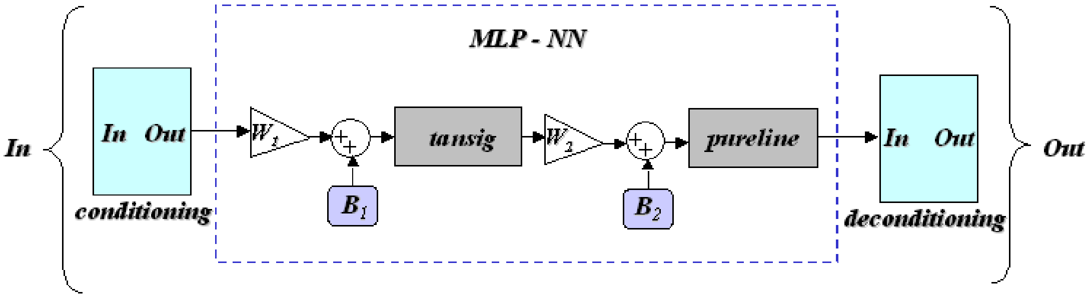

Fig. 4. Internal structure NNE.

The main three algorithms (training, validation and testing) of the NN pH estimator are presented as follows (Fig. 5).

For such problems, where the MLP-NN is proposed to estimate the pH, there is no general method to fix the architecture of the network (number of neurons in the hidden layer). In this case, we are going to study certain number of neuronal architectures.

For each architecture, we do different initializations of synaptic parameters to assure that the training of the NN converges towards the total minimum of the error criterion. For each structure, we calculate the mean square error MSE in the training and validation data bases (as shown in Fig. 6).

Then, the adequate structure that we are concerned is the structure which has the least square error in the validation base (in our case is equal 0.01).

Fig. 6 presents the evaluation of the minimal MSE in the validation data base (in green color) that had been used to define the number of neurons in the hidden layer (in our case is equal 2) for the chosen structure.

For such application, we aimed to vary the number of neurons in the hidden layer from 1 to 20 neurons, as presented above in the x-axis for the relation between the MSE via the number of neurons in the hidden layer. And for each structure, three different initialisations of synaptic parameters had been carried out. The training had been done using Levenberg-Marquardt algorithm [3, 4].

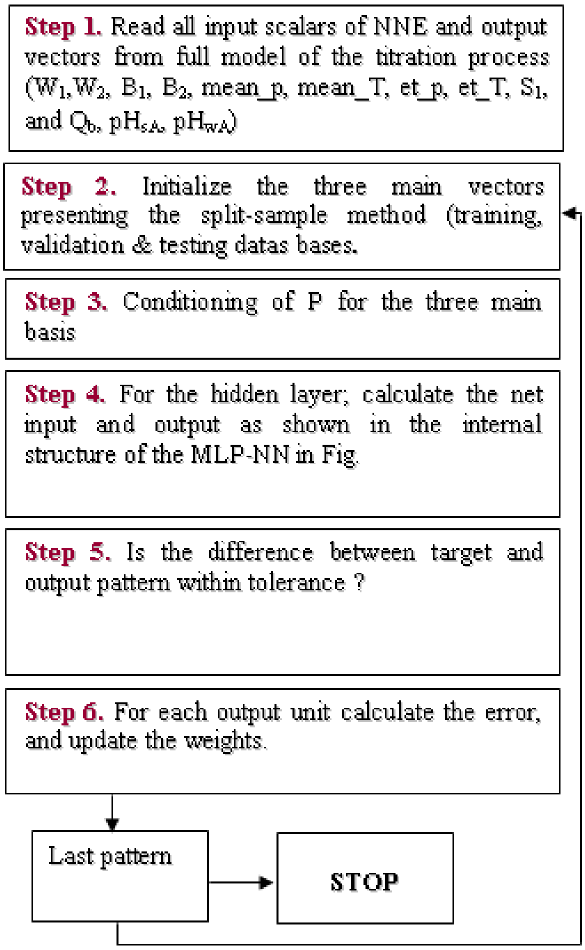

Fig. 5. Flow chart presents the NN three main algorithms (training, validation and testing).

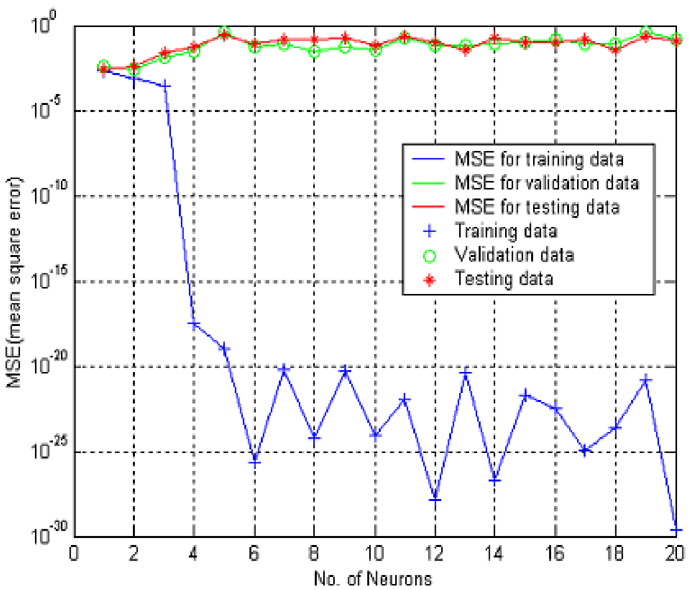

Fig. 6. MSE for both the training and validation data bases.

3.3. Interpretation of Results

Finally, the capacity of the net will be tested, with respect to extracted experimental data base, to find the estimated pH that corresponded to the least error between the estimated and ideal ones for different 200 values of input vectors.

The utilized examples had been subdivided into three stages (training (100), validation (68) and testing (32)) as performed by split-sample method [3].

The testing data base is of different values than the precedent ones (training and validation data base).

The error between the real and estimated speed values is defined for each parameter by the relative error *ER*(pH) calculated by the following formula (1),

$$ER(pH) = \sqrt{\frac{1}{N}\sum_{i=1}^{n}\left[\frac{pH' - pH}{pH}\right]^2}, \quad (1)$$

where N is the number of considered points (in our case is equal 32).

For the proposed design, it had been found that the relative error is 0.02 %, which is accepted. So the designed MLP-NNE has a sufficient value of accuracy.

4. Results

After design steps and net training, the performance of the proposed estimator that calculates the pH values with respect to the base flow measurements in l/min has been tested and then validated numerically, as following (Fig. 7):

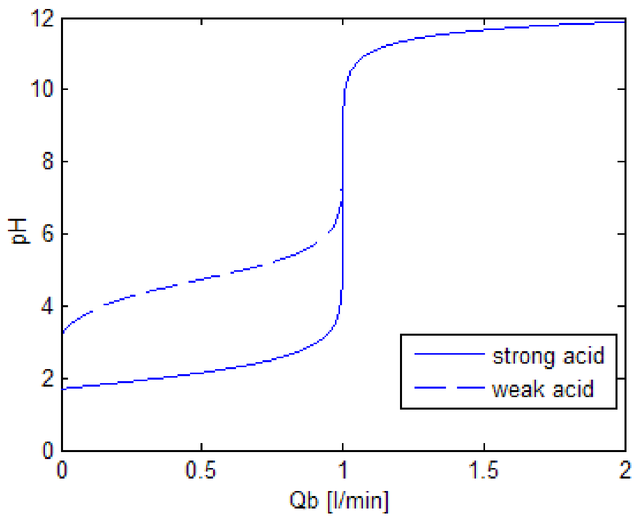

Fig. 7. The estimated curves for strong based strong/weak acid.

It was found, when comparing with ideal curves (Fig. 8), that the numerical proposed estimator is well performed. And the results are being satisfied.

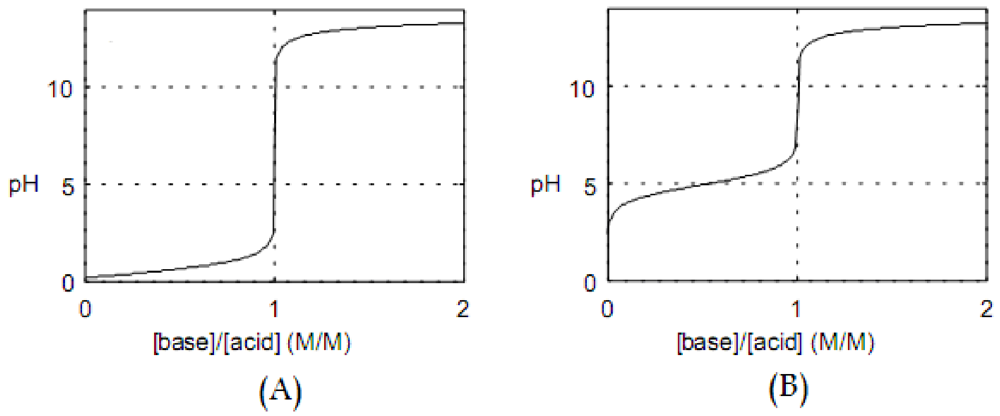

Fig. 8. The ideal curves for strong based strong/weak acid (A and B respectively).

5. Conclusions and Perspectives

- The proposed structure for MLP-NNE has been designed to solve the varieties of troubles might be found with the real hardware (pH electrode) and convention methods for evaluation of pH.
- The effectiveness of the proposed observer has been ensured as well concluded when comparing Fig. 7 (estimated titration curve) with Fig. 8 (ideal titration curve).
- The proposed NN-based pH estimator if implemented experimentally will optimize the size of overall plant with cost reduction to meet the industrial enquiries. And this is one of perspectives of the present work.

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Guide for Contributors

Aims and Scope

Sensors & Transducers Journal (ISSN 1726-5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In additional, some special sponsored and conference issues published annually. *Sensors & Transducers Journal* is indexed and abstracted very quickly by Chemical Abstracts, IndexCopernicus Journals Master List, Open J-Gate, Google Scholar, etc.

Topics Covered

Contributions are invited on all aspects of research, development and application of the science and technology of sensors, transducers and sensor instrumentations. Topics include, but are not restricted to:

- Physical, chemical and biosensors;
- Digital, frequency, period, duty-cycle, time interval, PWM, pulse number output sensors and transducers;
- Theory, principles, effects, design, standardization and modeling;
- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
- Sensors interfaces, buses and networks;
- Signal processing;
- Frequency (period, duty-cycle)-to-digital converters, ADC;
- Technologies and materials;
- Nanosensors;
- Microsystems;
- Applications.

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Articles should be written in English. Authors are invited to submit by e-mail editor@sensorsportal.com 8-14 pages article (including abstract, illustrations (color or grayscale), photos and references) in both: MS Word (doc) and Acrobat (pdf) formats. Detailed preparation instructions, paper example and template of manuscript are available from the journal's webpage: http://www.sensorsportal.com/HTML/DIGEST/Submition.htm Authors must follow the instructions strictly when submitting their manuscripts.

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