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RESEARCH ARTICLE OPEN ACCESS

Improving Volume Control in Water Canning Industries Using ANN Feedback

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Abstract:

Can Water Industries are known to produces bottled water for the drinking pleasure of individuals, these industries employ lots of method in other to achieve the filling of the can water, packaging and selling. This research work focuses on the filling process; there is various method of filling the cans which could manually or automatically. It's being observed that these water can are not properly filled. In water canning industries, there are various techniques of to filling the water bottles. All aimed at getting the water level of the all the can bottles to a certain constant level of equality, which enhances the credibility of the company and customer relationship. The improper filling of can water has made these companies lose some of their customers. This is because the filling mechanism used is not efficient enough to detect unfilled bottles and send them back for refilling. This issue of under-filled Can Water is addressed by "Improving Volume Control in the Water Canning Industry using Feedback ANN". It is done in this manner, characterizing the subject understudy, training the values gotten from the mathematical model to monitor and control the filling of the cans, designing a model that will monitor and control the filling process, designing a model for improving volume control in water canning industry using feedback ANN control, comparing the result achieved with the conventional. The results obtained are conventional improper filling volume of can water in an industry is 48cl while the properly filled volume when ANN feedback is incorporated in the system is 50cl. The problem of inconsistency in filling can water has been overcome by the process of improving volume control in water can industries by closely monitoring the process and ensures that the cans are properly filled to its determined level.

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Keywords **—ANN, Distilled Water, Feedback, Flow Rate, Volume Control**

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I. INTRODUCTION

Lack of volume control in our can water industries has led to a lot of waste and even liquidation of some of these companies as customers tend to see the un-seriousness and incompetence of these companies by their products which lacks stability in their products. This happens as a result of the improper filling of the can bottles hence inspiring me to this research work; "Improving volume control in the water canning industry using feedback ANN controller".

This Dissertation presents an approach to improving the existing liquid volume control in bottling companies. Filling a bottle or a container with a liquid such as drinking water or distilled water, etc. to a precise volume is a complicated task carried out by liquid dispensers. This process is generally done automatically with bottling machines that fill bottles sequentially. Bottling machines are embedded with many control device that manages the water supply by sensing the presence of bottles, dilate the dispenser nuzzle, control the flow, and move the bottle conveyor accordingly. It is robust, speedy and can dispense a preset volume of water in the bottles as they move along the bottling lines.

Mechanized liquid dispensers have shortcomings like spilling of liquid while filling containers, unequal liquid level in the containers, delay in the production line, and reduced efficiency due to human and machine errors. The challenge is to embrace new automation and control techniques for precise liquid volume control and to accelerate the filling process without human operators and machine errors. This informed the need for an improved liquid volume control system with feedback Neural Network Controller. With a neural network controller, the input pattern of the system program is learned and the system begins to perform these very sensitive and specified functions unsupervised.

II. MATERIALS AND METHOD

Materials Used

Photoelectric Sensor

A photoelectric sensor is a device that uses an infrared transmitter and photoelectric receiver to detect the presence or absence of an object.

Sensor for liquid level

We built our own sensor to detect the amount of liquid in the overhead tank. It makes use of liquids' ability to carry electricity. The PLC detects this state to determine if the overhead tank is low on liquid or has enough liquid.

Relay

Our actuators (electro valve, pump, and DC gear motor) have different working voltages and currents than the PLC outputs, so relays are utilized to make the PLC output drive the actuators through an external power circuit. A relay is an electromagnetic switch that can turn on or off a substantially bigger electric current with a comparatively tiny electric current.

Other Hardware (Proximity Sensors)

The proximity sensor detects non-contact sensing of a metallic item using the PNP inductive proximity switch. Their operation is based on a coil and oscillator that generate an electromagnetic field in the immediate vicinity of the sensor surface (E. Ramsden, 2006). The oscillation amplitude is dampened when a metallic object (actuator) is present in the operating area. A threshold circuit that adjusts the sensor's output detects the rise or fall of such oscillations. The sensing characteristics are determined by the material being detected as well as the distance between the sensor and the item. The most efficient material is iron, whereas copper is the least efficient.

Design Method

An Artificial Neural Network is a neural network system with feedback channels, which means the signal, can flow in both directions via loops. As a result, it is a non-linear dynamic system that evolves continually until it achieves equilibrium (equal proportion). The human brain's processing is utilized as a foundation for developing algorithms that can be used to model complicated patterns and solve prediction challenges. Let's start with an overview of how the human brain processes information:

There are billions of neurons in the human brain that process information in the form of electric signals. The dendrites of the neuron receive external information/stimuli, which are processed in the neuron cell body, converted to output, and transferred through the Axon to the next neuron. Depending on the strength of the signal, the following neuron can either accept or reject it. Figure 1 illustrates this analogy.

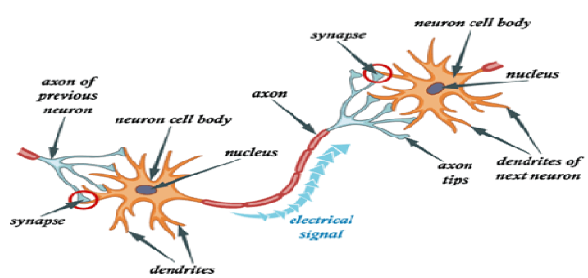


Figure 1: The Human Brain Model depicting the system

Step 1: External signal received by dendrites	**Step 2:** External signal processed in the neuron cell body	**Step 3:** Processed signal converted to an output signal and transmitted through the Axon	**Step 4:** Output signal received by the dendrites of the next neuron through the synapse

Now, let's try to understand how an ANN works:

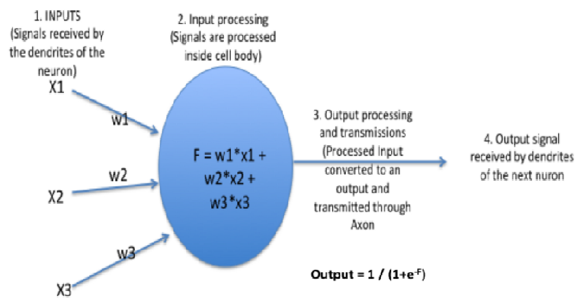


Figure 2: The Basics of an ANN System

The input signal strengths are represented by w1, w2, and w3. An ANN is a very simple representation of how a human brain neuron functions, as shown in figure 2.

Finally, the designed diagram of the overall system for the feedback control system of the caning industry can be seen below

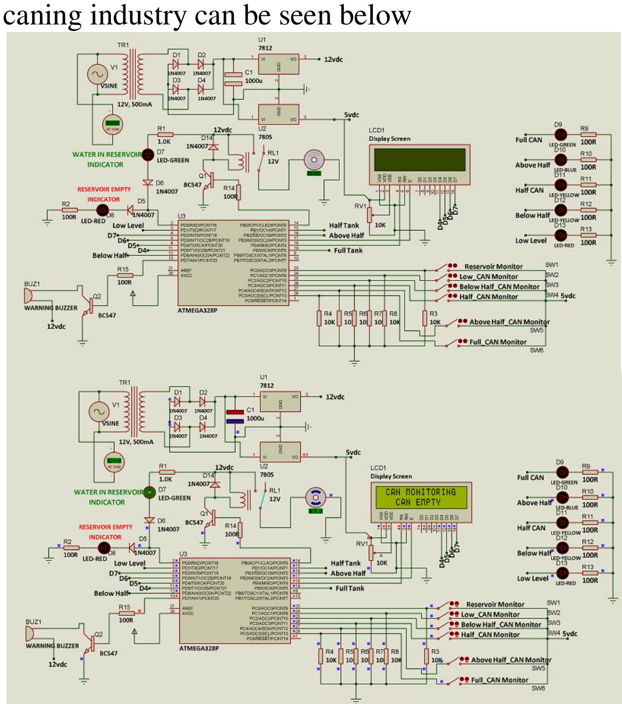


Figure 3: The overall designed system of the ANN CAN volume control system

III. IMPLEMENTATION OF THE DEVELOPED SYSTEMS

Model of the system:

To make things clearer, let's look at ANN through the lens of the proposed system (improving volume control in the water caning industry using feedback ANN controller). The stimulation levels of the water can and the water reservoir are the system's essential inputs.

Measurements and analysis of the characterized bottle shape were made and the values gotten were characterized geometrically as shown below:

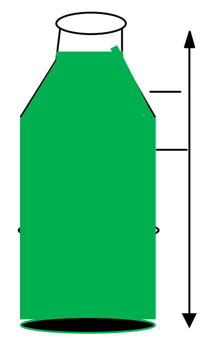
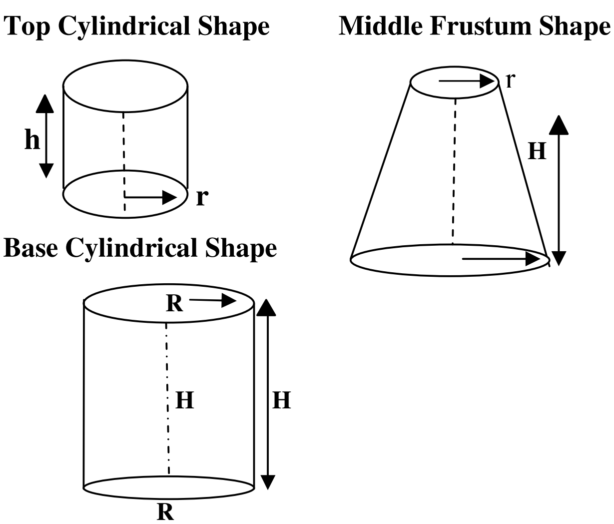


Figure 4 Bottle shape with cylindrical top, frustum neck, and cylindrical base



Figures 5: Bottle Geometry

The following parameters are for the shapes

R_B	3cm
H_B	15cm
H_F	5cm
h_T	5cm
r_T	1cm

(i) The radius of the topmost cylindrical shape
(ii) Highest of the topmost cylindrical shape
(iii) The radius of the top of the Frustum
(iv) The radius of the base of the Frustum
(v) Height of the Frustum
(vi) The radius of the base cylindrical shape
(vii) Height of the base cylindrical shape sum of the height of the top cylindrical shape, height of the Frustum, and that of the base cylindrical shape.
(viii) Pi (π) is a constant for circular shapes.

Mathematically, the volume of the base cylindrical shape.

$$V_B = \pi R^2 h \qquad (1)$$

The volume of a Frustum is given by

$$V_F = \underline{\pi h}\,(R^2 + Rr + r^2) \qquad (2)$$

Volume of the Top cylindrical shape is given as
$V_T = \pi r^2 h$
Where V_B = Volume of the base cylinder
V_T = Volume of the Top cylinder
V_F = Volume of the Frustum
R_B= Radius of base cylinder
r_t= Radius of top cylinder

Volume as a physical quantity is a function of height and radius which varies with bottle shape. In this work, the radius and the overall height of a bottle are represented in the table below for a chosen liquid volume of …. Cl.

$$V_{Full} = \pi r^2 h_T + \pi h_F\,(R^2_B + R_B r_T + r^2) + \pi R^2 h_B \qquad (3)$$

$V_{Full\ bottle} = 3.142 \times 1^2 \times 5 + 3.142 \times 5\ (3^2 + 3 + 1^2) + 3.142 \times 3^2 \times 15$

$V_{full\ bottle} = 15.71 + 5.236\ (13) + 424.17$
$= 15.71 + 68.068 + 424.17$

$V_{full\ bottle} = 507.948\ cm^3$

Approx 50.8cl

Ideally, liquids are not filled to the brim. Beverage companies do allow vacuums that are filled with methane gas or carbon dioxide to inhibit microorganisms from contaminating the contents. Standard volumes are maintained around 40 percent of the topmost cylindrical shape as it is in the shape of the bottle under study. This will also suggest the specific liquid volume that is read from the weight in the weight sensor display. Though this is monitored automatically by the neural network program in the Programmable Logic Circuit

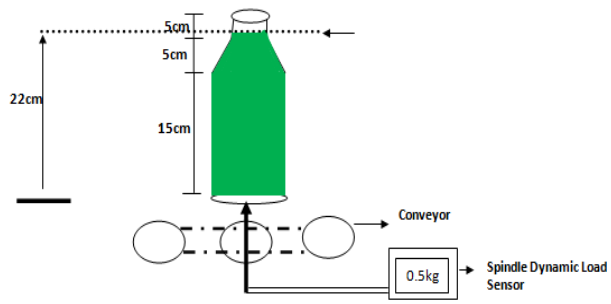


Figure 6 Weight Sensor position for a specified liquid level

Recall that our mathematical model for the bottle shape with triple geometry is given by:

$$V_{full\ bottle} = \pi r^2 h_T + \pi h_F(\underline{R^2_B + R_B r_T + r^2_T}) + \pi R^2_B h_B \qquad (4)$$

To achieve a liquid height of at least 40 percent of the topmost cylindrical shape, the height of the topmost cylindrical shape h_f will be taken to be 2cm.
Therefore volume at 22cm height will be the ideal liquid level

$V_{Liquid\ level} = 3.142 \times 1^2 \times 2 + \underline{3.142} \times 5\ (3^2 + 3 + 1^2) + 3.142 \times 3^2 \times 15$

$= 6.284 + 68.08 + 424.17 = 498.53$
Appro= 50cl
This volume of water of density $1000kg/cm^3$ is given by

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \qquad (5)$$

Weight = Mg = Volume x density
Therefore the algorithm for a specified liquid volume and weight is given by

$\text{Weight} = \{V_{full\ bottle} = \underline{\pi r^2 h_T} + \pi h_F\ (R^2_B + R_B r_T + r^2_T) + \pi R^2_B h_B\}.\ \text{density}$

$$= V_{full\ bottle} = \pi r^2 h_T + \pi h_F(R^2_B + R_B r_T + r^2_T) + \pi R^2_B h_B \times 1000\ kg/cm^3 \qquad (6)$$

Flow Rate

From the law of conservation of mass (continuity), the density and volume of a fluid change \with the shape of the object within the domain of time. In this work, the diameter of the nozzle used is 0.6cm and the speed of water delivered through the nozzle is 7.98m/s, hence the mass flow rate was determined thus:

$$\text{Mass flow rate} = \frac{\text{Mass}}{\text{Time}} = \text{Density x Area x Velocity}$$

$$\text{Where Density} = \frac{\text{Mass}}{\text{Volume}} \qquad (7)$$

Therefore, the flow rate in volume per unit time is given as below;

$$\frac{\text{Volume}}{\text{Time}} = \text{Area x Velocity}$$

Area of the nozzle $= \pi r^2$ where $\pi = 3.142$ and r = 0.003m (8)

$= 3.142 \times 0.003 \times 0.003$

$= 0.00002823m^2$

The flow rate of the dispenser is obtained as below;

Flow rate $= 7.98 \times 0.00002823$

$= 0.0002013m^3/s$

$= 0.2013cl/s$

$= 20cl/sec$

Valve Dilation / Opening

Table 1 below shows the distributions of flow rate, bottle calibration, and valve opening

Time (s)	**Dilation Angle (°)**	**Flow Rate (cl/sec)**	**Volume (cl)**
1	90	20	20
2	67.5	15	35
3	22.5	5	40
4	22.5	5	45
5	13.5	3	48
6	9	2	50

Design Components

Load sensor – point load sensor
- Capacity: 0 – 20 kg
- Voltage rating: 24V

Photoelectric sensor
- detecting range: 10m
- position measurement: 10cm
- response time: 10ms

Solenoid valve
- Maximum dilation rate: 90cl per second

Conveyor
- 12V dc motor
- 200rpm at 12V operational voltage
- 2.5kg per cm torque
- 1/30 gear reduction ratio

Relay
- nominal voltage: DC 12V

Liquid Level Sensor
- four(4) nodes: upper, middle, lower, and common nodes
- voltage rating: 24V DC

Simulink model designs for distributing 50cl of water in a bottling line.

Simulink is a graphical programming environment developed by MathWorks for modeling, simulating, and analyzing multi-domain dynamical systems. For multi-domain simulation and Model-Based Design, it is frequently utilized in automatic control and digital signal processing.

As can be seen in the diagram below, a model was created in the Simulink environment to implement the fluctuation of the dilation angle and flow rate in relation to the rise in the volume of a bottle being filled.

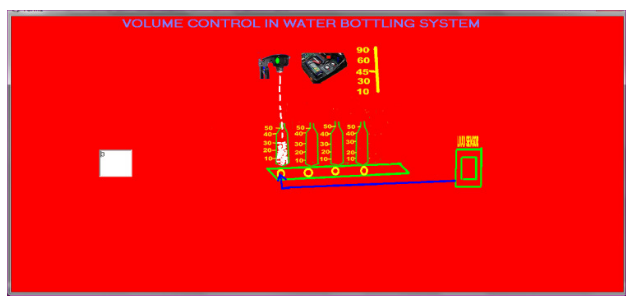


Figure 7: When the volume is 30m3, the valve opening is 45Designed Simulink model for volume control in water bottling using ANN feedback controller (visual basic). The remaining three bottles, on the other hand, are yet to be filled.

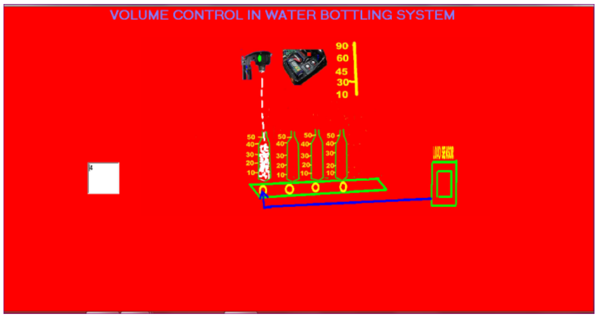


Figure 8: This shows that when the volume is 40m^3, the valve opening is 30. On the other hand, the rest three bottles are yet to be filled.

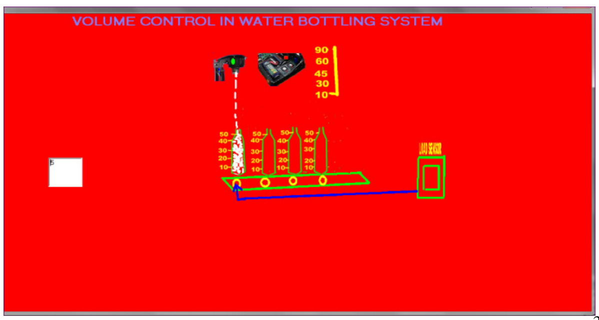


Figure 9: This shows that when the volume is 50m^3, the valve opening is 10. On the other hand, the rest three bottles are yet to be filled.

Training the dispenser used in bottling50cl of water understudy with Artificial Neural Network.

In artificial neural network training, there are two approaches; the supervised and the unsupervised. In this work the supervised approach of training was adopted as the desired output – the bottle volume is known and inputted into the system. The initial weights – the degree of dilation and the flow rate are also known and inputted. These inputs are what the system accepts, processes, and compares the output with the desired output, with this, the system adjusts in response and learns that pattern of behavior.

Table 2: Parameters for supervised training of ANN

Time(s)	**Valve Dilation Angle (°)**	**Flow Rate (cl/sec)**	**Output Volume (cl)**
1	90	20	20
2	67.5	15	35
3	22.5	5	40
4	22.5	5	45
5	13.5	3	48
6	9	2	50

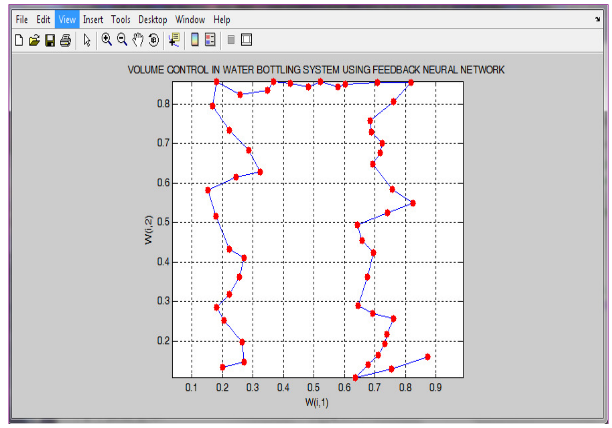


Figure 10: ANN training of volume control in water bottling system using feedback neural network

Fig 10: shows ANN training of volume control in a water bottling system using a feedback neural network. The standard volume of 50 was input in the ANN training tool which was trained once 50c1.

IV. RESULTS AND DISCUSSIONS

Table 3: Comparing conventional and feedback controller volume of water canny industries

Time(s)	Conventional volume of cane water	Feedback controller volume of cane water
0	0	0
1	30	31
2	40	42
3	45	48
4	48	50

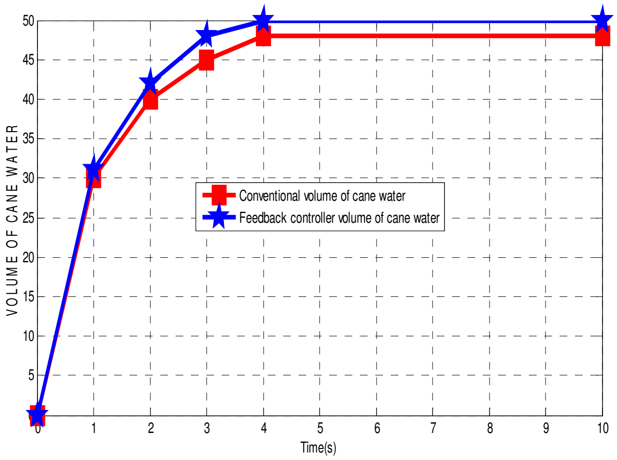


Figure 11: Compares Conventional and Feedback Controller Volume of Water Can Industries.

The conventional improper filling volume of canny water in an industry is 48cl while the properly filled volume when ANN feedback is incorporated in the system is 50cl.

Results

This section presented the simulation of the implemented model of the integrated adaptive noise canceller on the radio station. The simulation was done using the parameters in table 3 and achieved the results presented below for discussions.

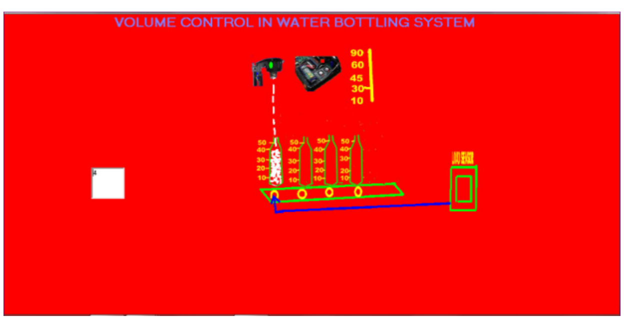


Figure 12: Designed Simulink model for volume control 1 in water bottling using ANN feedback controller (visual basic)

It simply shows designed Simulink model for volume control in water bottling using ANN feedback controller (visual basic) shows that when the volume is $40m^3$, the valve opening is 30. On the other hand the rest three bottles are yet to be filled.

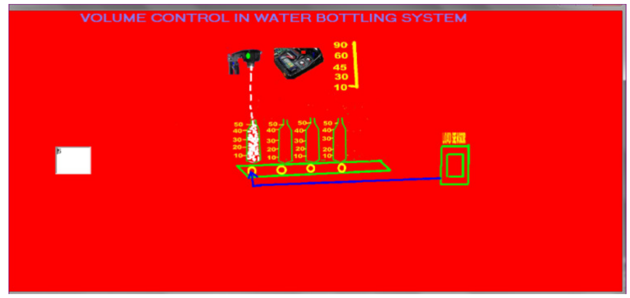


Figure 13: Designed Simulink model for volume control 2 in water bottling using ANN feedback controller (visual basic)

It shows designed Simu link model for volume control in water bottling using ANN feedback controller (visual basic) above fig shows that when the volume is $50m^3$, the valve opening is 10. On the other hand the rest three bottles are yet to be filled.

Table 4: Parameters for supervised training of ANN

Time(s)	Valve Dilation Angle (^{0})	Flow Rate(cl/sec)	Output Volume (cl)
1	90	20	20
2	67.5	15	35
3	22.5	5	40
4	22.5	5	45
5	13.5	3	48
6	9	2	50

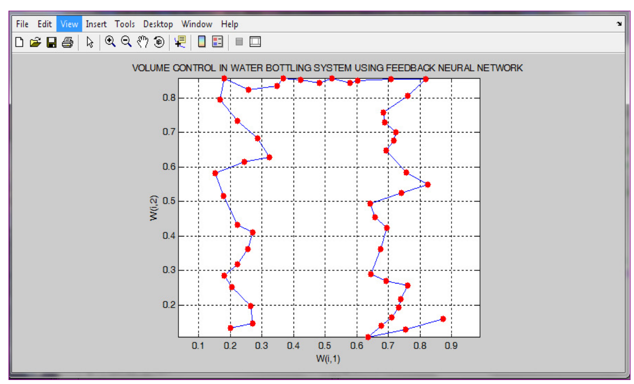


Figure 14: Ann Training of Volume Control in Water Bottling System Using Feedback Neural Network.

V. CONCLUSION

Some water can enterprises have gone out of business because their water is not properly filled to the needed requirement of 50cl. The water canning business's inappropriate filling of canny water is addressed by implementing improved volume control in the water canning industry utilizing an ANN feedback controller. Characterizing the subject under study, training the values obtained from the mathematical model to monitor and control the filling of the cans, designing a model to monitor and control the filling process, designing a model for improving volume control in the water canning industry using feedback ANN control, and comparing the results with the conventional are the steps taken. The results show that the usual inappropriate filling volume of canned water in a factory is 48cl, while the properly filled amount is 50cl when ANN feedback is used.

Recommendation

The improper filling of canny bottled water is a result of not having an appropriate filling mechanism that would detect when the canny bottle is not properly filled and feed it back for refilling.

In near future, a more intelligent format that has a feedback controller can be imbibed into the system.

VI. CONTRIBUTION TO KNOWLEDGE

This research work will greatly contribute to the improvement of water CANN Industries if implied because when the can bottle are properly filled it gives a satisfactory result both to the company and customers purchasing them thereby enhancing the productivity of the company and its customer relationship.

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