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FUZZY LOGIC DESIGN OF CONTINUOUS INTRAVENOUS INFUSION CONTROL

Vijay Pal Singh & Mahesh K. Yadav

Abstract

Intravenous therapy is the infusion of liquid substances directly into veins. The infusion rate must be controlled. If the infusion rate is below or above the required rate it can be dangerous. Presently the infusion rate is being controlled manually. But the infusion rate can also be controlled automatically using the concept of Fuzzy Logic. To control the infusion rate there are many parameters to be considered. To control the infusion rate, there are many parameters, which can be considered. In this paper four parameters namely Heart Rate, Hemoglobin, Body Temperature and Weight of cattle are incorporated to control the infusion rate.

Keywords: Intravenous therapy, Infusion rate, Fuzzy Logic, Heart Rate, Infusion Control, Body temperature.

1. Introduction

Intravenous therapy is the administration of liquid directly into veins. It can be intermittent or continuous; continuous administration is called an intravenous drip. The word intravenous simply means "within a vein", but is most commonly used to refer to IV therapy. Compared with other routes of administration, the intravenous route is the fastest way to deliver fluids and medications throughout the body. Some medications, as well as blood transfusions and lethal injections, can only be given intravenously.

An intravenous drip is the continuous infusion of fluids, with or without medications, through an IV access device. This may be to correct dehydration and electrolyte imbalance or to deliver medications.

1.1 Intravenous Fluids

There are two types of fluids those are used for intravenous drips; crystalloids and colloids. Crystalloids are aqueous solutions of mineral salts or other water-soluble molecules. Colloids contain larger insoluble molecules, such as gelatin; blood itself is a colloid.

The most commonly used crystalloid fluid is normal saline, a solution of sodium chloride at 0.9% concentration, which is isotonic to blood. A solution of 5% to 20 %

dextrose in water is often used instead if the patient is at risk for having low blood sugar (hypoglycemia) or high sodium. The choice of fluids may also depend on the chemical properties of the medications being given[5].

1.2 Infusion Equipments

In the traditional IV infusion sets [Fig. 1.] the drip is left to flow simply by placing the bag above the level of the patient and using the clamp to regulate the rate; this is a gravity drip.

A standard IV infusion set consists of a pre-filled, sterile container (glass bottle, plastic bottle or plastic bag) of fluids with an attached drip chamber which allows the fluid to flow one drop at a time [Fig. 2.], making it easy to see the flow rate (and also reducing air bubbles); a long sterile tube with a clamp to regulate or stop the flow; a connector to attach to the access device; and connectors to allow "piggybacking" of another infusion set onto the same line, e.g., adding a dose of antibiotics to a continuous fluid drip.

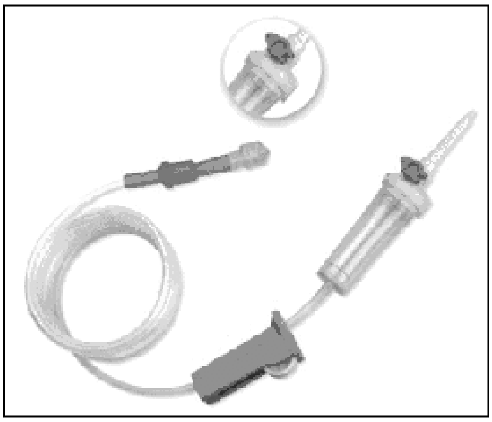

Figure 1: Traditional IV Set

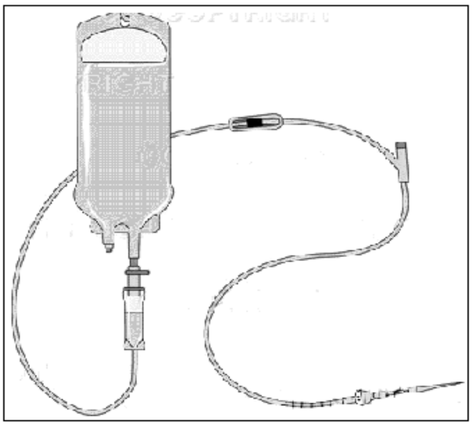

Figure 2: Use of Traditional IV Set

It is very important that the temperature of liquid to be infused must not be below body temperature of cattle. If the liquid below body temp is infused, it may cause Hypothermia. To avoid this condition a heating device is incorporated in setup which maintains liquid around body temperature.

2. NEED TO CONTROL INFUSION RATE

When fluids are given at a higher rate or in a larger volume than the system can absorb or excrete then Fluid Overload Occurs. Possible consequences include hypertension, heart failure and pulmonary edema etc.

Hypervolemia (or "Fluid overload") is the medical condition where there is too much fluid in the blood.

- This fluid, primarily salt and water, builds up in various locations in the body and leads to an increase in weight, swelling in the legs and arms (peripheral edema), and/or in the abdomen (ascites).
- Eventually, this fluid enters the air spaces in the lungs, reduces the amount of oxygen that can enter the blood, and causes shortness of breath (dyspnea).

On the other hand if rate of infusion is very low then it may happen that the requirements of patient would not be fulfilled in time. Due to this the condition of patient may be worsen.

3. Control of IV Infusion Rate Using Fuzzy Logic

In traditional sets the surgeon controls the infusion rate using the regulator manually. Here we are simulating to control the infusion rate using fuzzy logic. There may be many parameters which are to be considered to control the infusion rate, but presently we are considering only four parameters.

1. Heart Rate
2. Body Weight
3. Hemoglobin
4. Body Temperature

If the Heart Rate is low then the absorption rate is low so the infusion rate must be low. In the case of body weight if body weight is low then blood volume in the body is also low so absorption is also slow and hence infusion rate. We can give continuous input of Heart Rate by using ECG.

The hemoglobin molecule is the primary transporter of oxygen in mammals and many other species. Hemoglobin parameter (H.B) shows the density of blood. If H.B is low the the Infusion Rate must be low otherwise dilution attack may occure.

Body Temperature in cattles remains constant (Approx. 101.5° C). If Body Temperature goes up or down then it is a physical disorder. There may be mainly two reasons of rise in Body Temperature. It may be due to Infection or due to Dehydration or Heat strock. Here we have considered only the case of Infection. In this case we give only normal saline(a solution of sodium chloride at 0.9% concentration) with required antibiotics.

3.1 Input and Output Parameters

We are taking Body Temperature, Weight, Heart Rate and Hemoglobin as input parameters and Infusion Rate as output parameter [Fig. 3.]. Body Temperature is taken in °C, Weight is taken in Kilograms,Heart Rate is taken in Beats/Minutes and Hemoglobin is taken in gms/decilitre. Infusion Rate is taken in ml/Minute.

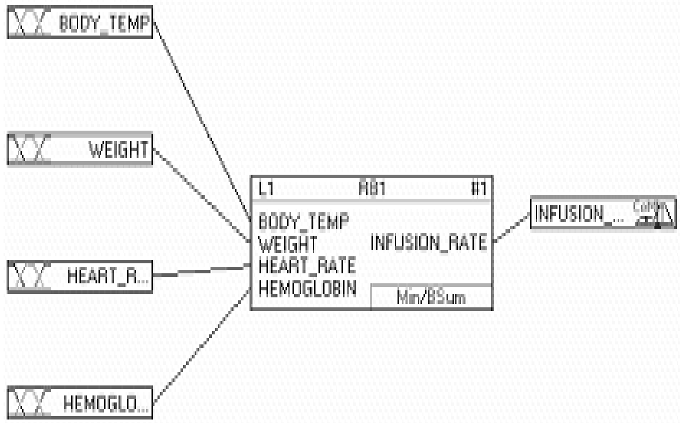

Figure 3: Input and Output Parameters

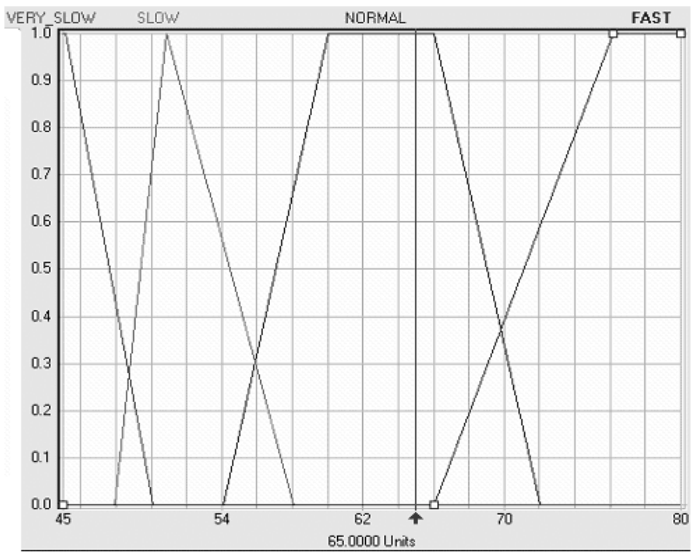

Figure 4: Membership Functions of Heart Rate

3.2 Fuzzification

Range of Heart Rate is from minimum 45 per minute to maximum 80 per minute. The whole range is distributed in four levels namely VERY_SLOW,SLOW, NORLAL and FAST. The membership functions are shown in Fig. 4.

Range of Weight is from minimum 150 Kg. to maximum 400 Kg. The whole range is distributed in four levels namely VERY_LIGHT, LIGHT, MODERATE and HEAVY. The membership functions are shown in Fig. 5.

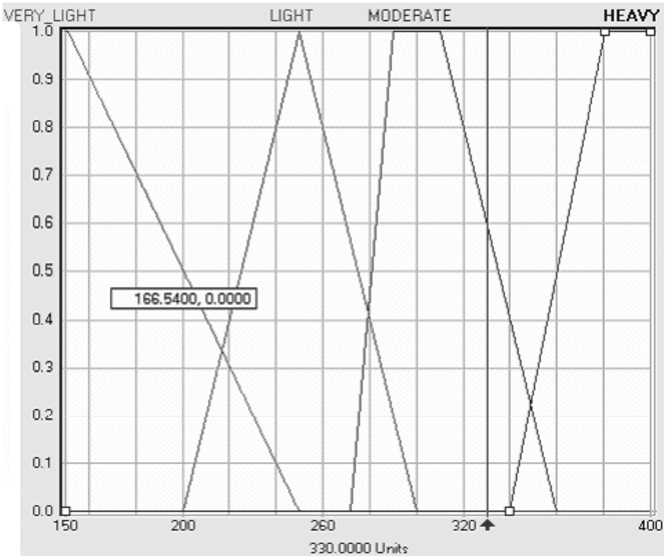

Figure 5: Membership Functions of Weight

Range of Body Temperature is from minimum 94°C to maximum 107°C. The whole range is distributed in four levels namely VERY_LOW, LOW, GENERAL and HIGH. The membership functions are shown in Fig. 6.

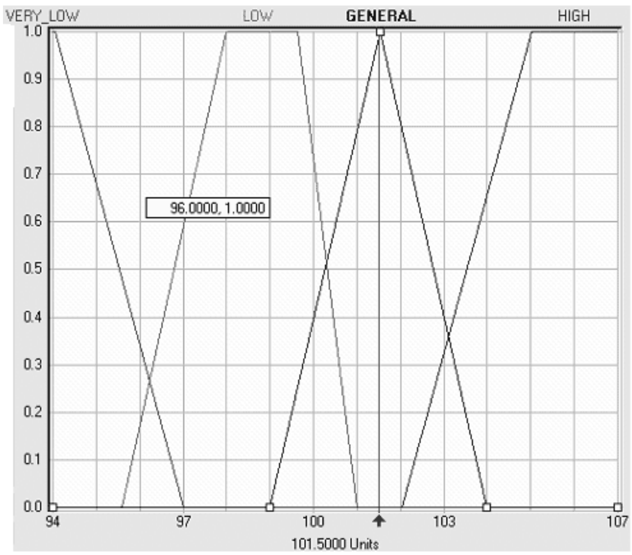

Figure 6: Membership Functions of Body Temp

Range of Hemoglobin is from minimum 6 gms/decilitre to maximum18 gms/decilitre. The whole range is distributed in four levels namely LOW, MEDIUM_LOW, MEDIUM_HIGH and HIGH. The membership functions are shown in Fig. 7.

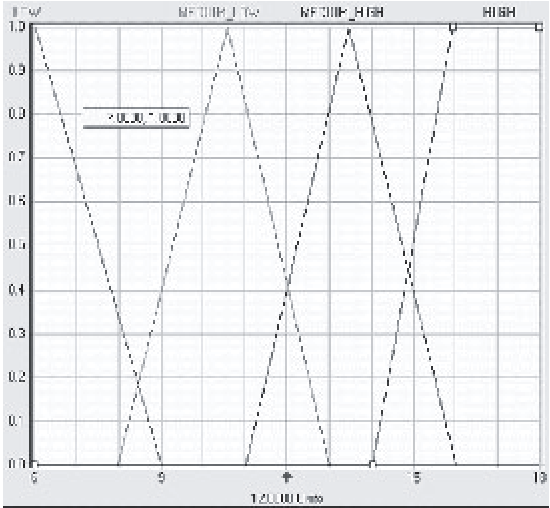

Fig.7 Membership Functions of Hemoglobin

Range of Infusion Rate is from minimum 12 ml/minute to maximum 36 ml/minute. The whole range is distributed in four levels namely SLOW, MEDIUM_SLOW, MEDIUM_FAST and FAST. The membership functions are shown in Fig. 8.

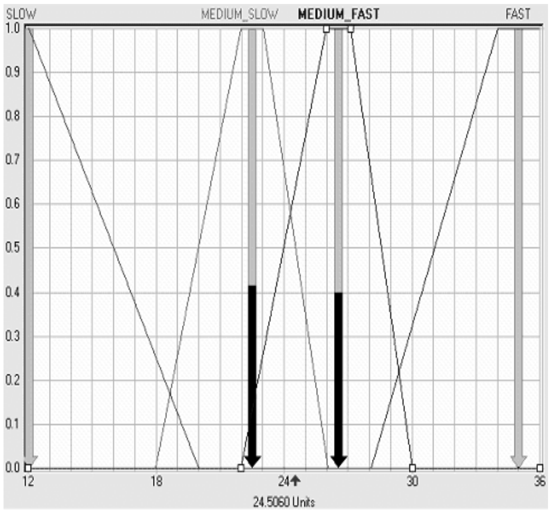

Fig.8 Membership Functions of Infusion Rate

3.3 Defuzzification

In this step we calculate the crisp value of the fuzzy system. There are various methods for the method of calculation crisp values; here we have used the centre of maximum (CoM) defuzzification method for simulation of results [2], [3]. The input aggregation is minimum and the output aggregation used is maximum.

4. SIMULATION RESULTS & DISCUSSION

This analysis simulation was programmed using Inform Software Corporation's fuzzyTECH 5.7. Every input was divided into four sets. The simulation results use 256 rules which are placed at Appendix. The summary of results is shown in Table 1.

Table 1 Infusion Rate in 10 Different Cases

Sl. No.	*Body_Temp*	*Weight*	*Heart_Rate*	*Hemoglobin*	*Infusion_Rate*
1	101.5	300	65	12	24.5
2	103	350	70	14	25.9
3	98	250	50	14	26.5
4	106	200	80	10	22.5
5	107	225	45	8	12.0
6	96	175	80	6	25.2
7	100	400	80	14	32
8	94	230	45	6	22.5
9	107	280	50	8	17.0
10	104	330	75	16	26.6

The surface curve for the four input parameters and one output parameter are shown in Fig. 9, 10, 11 and 12.

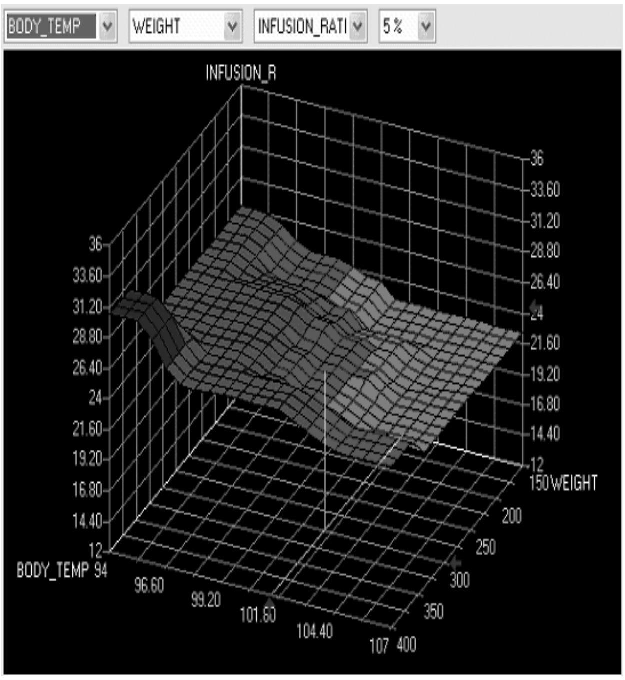

Figure 9: Surface Curve for Input Parameter "Body Temperature", "Weight" and Output Parameter "Infusion Rate"

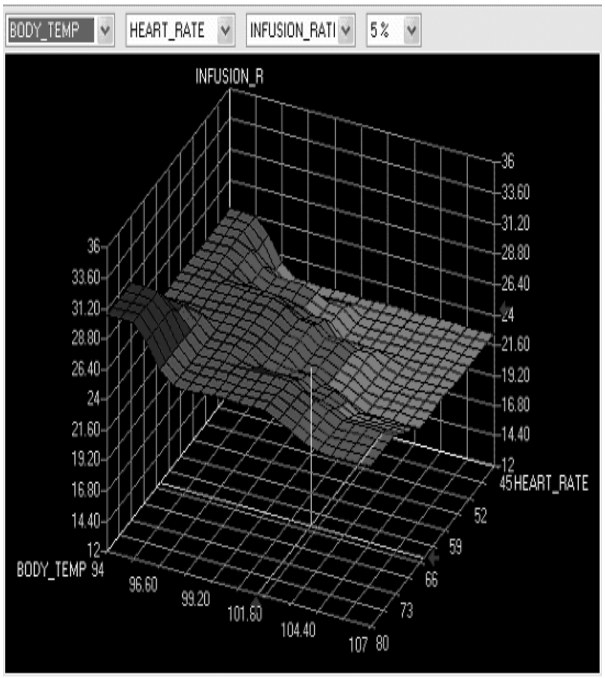

Figure 10: Surface Curve for Input Parameter "Body Temperature", "Heart Rate" and Output Parameter "Infusion Rate"

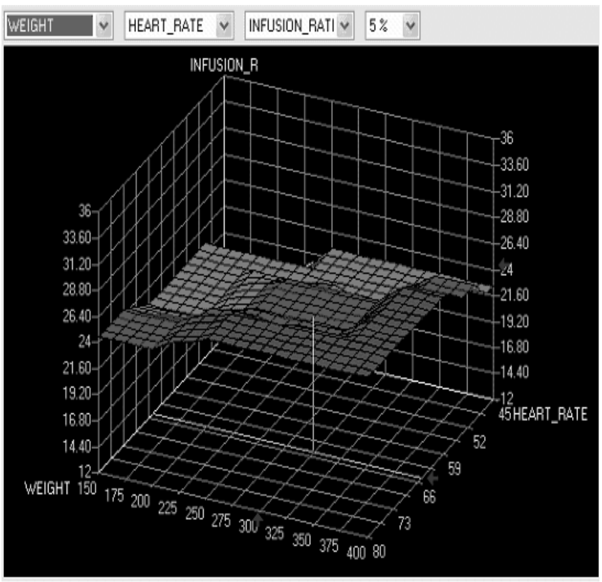

Figure 11: Surface Curve for Input Parameter "Weight", "Heart Rate" and Output Parameter "Infusion Rate"

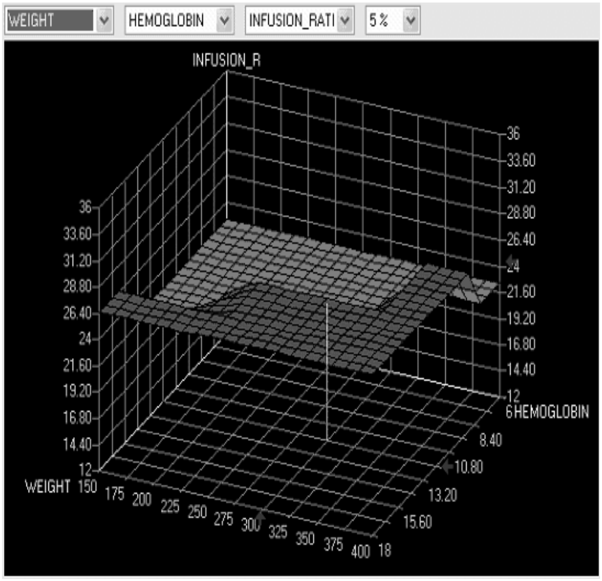

Figure 12: Surface Curve for Input Parameter "Weight", "Hemoglobin" and Output Parameter "Infusion Rate"

5. CONCLUSION AND FUTURE SCOPE

Fuzzy logic is a problem solving control system methodology that can be further implemented in hardware. In this paper we have used our system for ten different cases to give the infusion rate. This concept can be further implemented by using the sensors for all input parameters and the output can be used to control the flow through Electronic Infusion Regulators.

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Vijay Pal Singh[1] & Mahesh K. Yadav[2]
ECE Department, BRCM CET, Bahal, M. D. University, Rohtak, Haryana, INDIA
ECE Department, BRCM CET, Bahal, M.D University, Rohtak, Haryana, INDIA
E-mail: vijaybrcm@rediffmail.com[1] & mkyadav.mahesh@gmail.com[2]