Experimental Study of the Performance Test for the Infusion Monitoring System

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***Abstract*—Comparison with conventional manual adjustment to control the drop speed in clinical infusion, the infusion monitoring system can achieve much more high reliability and efficiency, and is easy to realize the automation of infusion. So the infusion monitoring system has been designed in the last papers. To test the designed system performance, some experiments are done. And the result show that under requirement of the system precision, the time consumption increase with the incensement of speed difference value; Comparing to the conventional PID controller, the fuzzy-PID controller can achieve high precision and little stabilizing time consumption.**

Keywords-infusion monitoring system; system precision; stabilizing time; experimental study

I. INTRODUCTION

Intravenous infusion dispensation is widely used in clinical treatment[1][2], However, Manual adjustment to control drop speed with the character of inadequate accuracy, inconvenience, infusion abnormal and end is difficult to find, is usually adopted in most hospital over many decades and maybe cause medical malpractice[1][3] [4][5] [6][7] [8][9]. In recent years, the more attention of researchers is pay on the automatic infusion system [6][8] [10].

In the last papers, the infusion monitoring system is designed based on the STM32F103 microcontroller, but a little experiments has been done, so in this paper, the experiment for system performance test is done, it includes system precision test, time consumption test, and comparison under different control arithmetic. At last, the experimental data is analyzed and some conclusions are achieved in this paper.

II. THE DESCRIPTION OF DESIGNED INFUSION MONITORING SYSTEM

The infusion monitoring system is illustrated in figure 1. The whole system is consisted of the control module, step motor and its driver, sheave, infusion bottles and infusion monitoring sensor. The infusion bottles can be pull up or down by step motor to adjust the infusion speed, while the infusion monitoring sensor can real-time measure the drop speed and the speed signal is sent to microcontroller after the process of signal shaper.

In the control module, the control core is the STM32F103 microcontroller, and the expand keyboard of the STM32F103 is used for the input of preset speed or other command, LCD module is used for the real-time display of drop speed and infusion residual quantity. The ADC module, as the Peripheral of STM32F103, is in charge of conversion from analog to digital. The PWM signal, produced by the PWM module, is sent to step motor driver and drive the motor to rotate. The infusion speed sensor, adopted in this system, is one pairs of the infrared emitting and receiving diode.

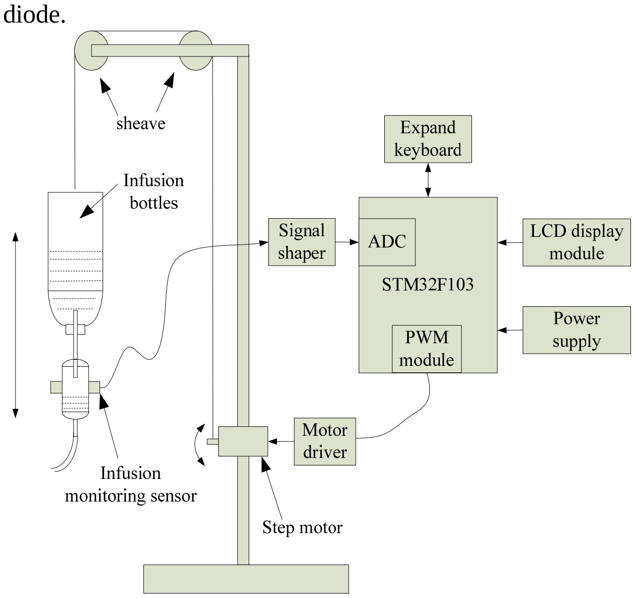

Figure 1 the infusion monitoring system

III. PERFORMANCE TEST PLAN FOR THE DESIGNED SYSTEM

For the designed system, the important parameters are the system precision and stabilizing time. However, in the actual infusion control system, if it needs to improve the precision, the stabilizing time would be increasing, so there is always a contradiction between the precision and stabilizing time. So the eclectic performance is finished through the application of some intelligent control methods.

So in this paper, the experiment is done to test the system precision, the stabilizing time and the performance in different control arithmetic. The test instrument and conditions is illustrated in table 1.

Table 1 test instrument and conditions

item	Parameters
Time scale	The Precision Professional Stopwatch (PC6230), with the character of tow rows display, 1/100 second, and measure

	up to 9 hours 59 minutes and 59.99 seconds, 30 recallable lap and split memories.
Height scale	Meter stick
Test conditions	Indoor with straight background-light
Speed checking	Manual scale after infusion speed stabilized
System parameters	The adjusted range of infusion bottles height : 20cm-150cm, the infusion speed: 20 - 140 (drops per second, and called dps in follows)

IV. EXPERIMENT AND DATA ANALYSIS

A. system precision test without regard to the adjusted time

Without considering the stabilizing time, the system precision test with the same speed difference value between the current speed and preset speed is firstly done for ten times and the data error for every times is shown in figure 2. when the speed difference value is 20dps, the maximum and minimum value of adjusting error are separately 13% and 3.3% and the average error is 5%; while the speed difference value is 40dps, the maximum and minimum value are separately 7.5% and 2.5% and the average error is 9%. So from the figure, we can infer that the error percentage will increase with the decrease of the speed difference value.

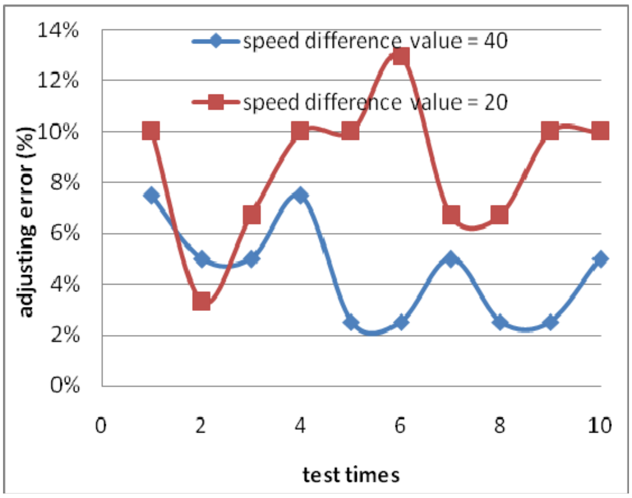

Figure 2 the adjusting error with the same speed differences value and the initial speed =50 dps

Under ignoring the stabilizing time, the stabilizing precision test is done with initial speed = 50 dps and preset speed =80 dps, the data is shown in figure 3, so we can see that it is 160s that system precision enter into stabilizing state.

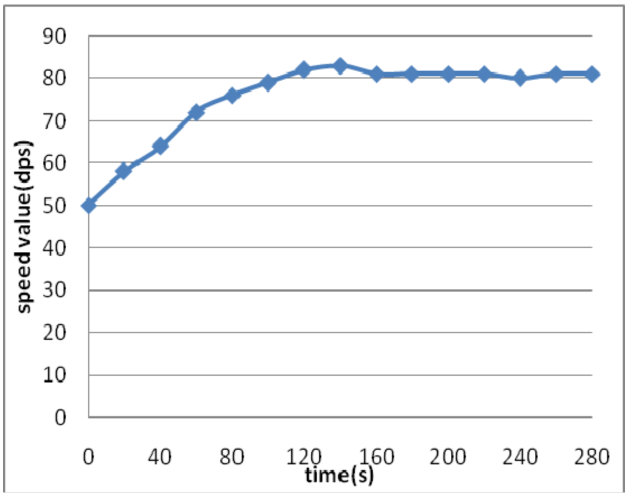

Figure 3 precision test with initial speed = 50 dps and preset speed =80 dps

At last, the dynamic test for the designed system with the initial speed =20 and difference value =30 is done, and the data is illustrated in table 2. In this experiment, if the current speed value is 48 dps, the next test initial speed is 48dps and the preset speed value is 78dps, and so on. From this table, the adjusting error is restively small and can meet the system requirement.

Table 2 experimental result for infusion speed with the initial speed = 20 dps

preset speed (dps)	Adjusted speed(dps)	Speed error(dps)	Error percentage
50	48	2	6.7%
78	79	1	3.3%
109	108	1	3.3%
138	136	2	6.7%
106	105	1	3.3%
75	73	2	6.7%
43	44	1	3.3%

B. The stabilizing time test under the requirement precision

Under the meeting for the requirement of system precision, the stabilizing time is done and the speed difference value are separately 10dps, 20dps, 20dps, 30dps, 40dps, 50dps, 60dps, 70dps, 80dps and 90dps, the initial speed is 50dps, the experiment repeat ten times for every speed difference value and finally the average value is used for curve plotting. The experimental result is shown in figure 4.

From the figure, the time consumption increase with the incensement of speed difference value except that the speed difference value is 10 dps, and this is up to ours prediction.

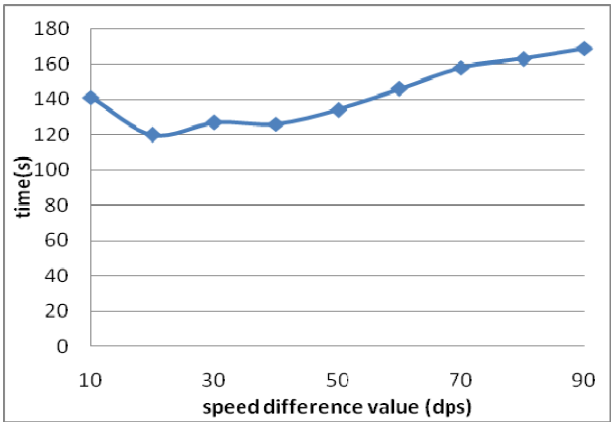

Figure 4 The stabilizing time with different speed difference value and the initial speed = 50

C. system performance test under different control arithmetic

A proportional–integral–derivative controller (PID controller) is a generic control loop feedback mechanism (controller) widely used in industrial control systems – a PID is the most commonly used feedback controller. However, the parameters of Proportional gain, integral gain and derivative gain cannot be modified on line in actual system. The fuzzy control can achieving high robust and isn't lie on the precise mathematic module [11][12] [13]. So the fuzzy-PID controller combined the PID controller with the fuzzy controller, is designed and applied into this system.

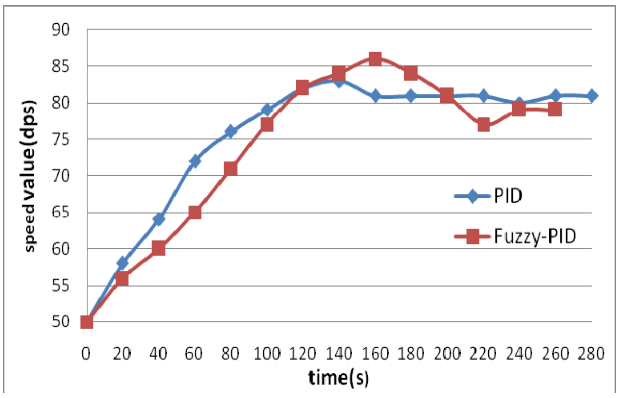

Figure 5 the performance comparison between PID and the fuzzy-PID controller

To comparing the performance between the PID controller and the Fuzzy-PID controller, the experiment is done, and the result is shown in figure 5. For the fuzzy-PID controller, the stabilizing time is 160s; while the stabilizing time is 240s for the PID controller.

V. CONCLUSIONS

Based on the designed infusion control system, some experiments are done and the data is canalized, the conclusion is illustrated as follows:

- If the stabilizing time is ignored, the system can achieve high precision and the error and error percentage can separately reach to 1 dps and 2.5%.
- Under requirement of the system precision, the time consumption increase with the incensement of speed difference value.
- Comparing to the conventional PID controller, the fuzzy-PID controller can achieve high precision and little stabilizing time consumption.

Generally, the designed system can be widely used in monitoring and management in the course of the infusion to advance the working conditions of medical staffs and reduce the medical errors in the small hospitals.

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