DESIGN OF A REMOTE CONTROLLED LIQUID MEDICINE DISPENSER

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INTRODUCTION

State funded free health facilities are of immense value to many Sri Lankans. Rich or poor, these quality health facilities have saved many lives over the past. Well qualified doctors, trained nursing staff as well as adequate and timely supply of drugs have been the key ingredients in maintaining these standards.

However, it is a well accepted fact that Sri Lanka is recently experiencing a severe shortage of professionals such as doctors and nurses (De Silva, *et al*., 2010). With the increasing population and also with the increasing medical requirements, this problem has grown to a non-negligible situation. Without adequate nursing staff, treating the patients and dispensing medicine on time have started to deteriorate from the maintained standards.
In order to address this issue, this paper presents a remote controlled liquid medicine dispenser, which will enable the doctor or the nurse to remotely order the required amount of liquid medicine to be dispensed to each and every patient via a global system for mobile communication (GSM) network's short message service (SMS) framework. The remote control feature available here which is novel to automatic medicine dispensers would make the proposed system superior to many other automated liquid medicine dispensing systems available today (Borel, 1995 & Lee, 1992 & Klibanov, 2003).

The system's characteristics allow the nurse to store the generated short messages and re-issue them as required, which will relieve the nurse's workload. Consequently, a single nurse would be able to dispense liquid medicines for many patients in a lesser time. Moreover, the same system can be deployed for multiple liquid medicine types and in multiple applications; either to inject medication intravascular or to dispense orally taken liquid medicine to a cup.

DESIGN METHODOLOGY

The proposed liquid medicine dispensing system consists of a mechanical arrangement to which a syringe can be fixed, a GSM modem for receiving the short message and also a control circuit to control the overall operation (Figure 1). The nurse can send a short message to the GSM modem using the predefined message format (Figure 2) and upon the reception of the short message at the GSM modem, the message is forwarded to the control unit. PIC 16F877 microcontroller based control unit then checks for the message validity and extract the dispensing volume and rate information from the message.

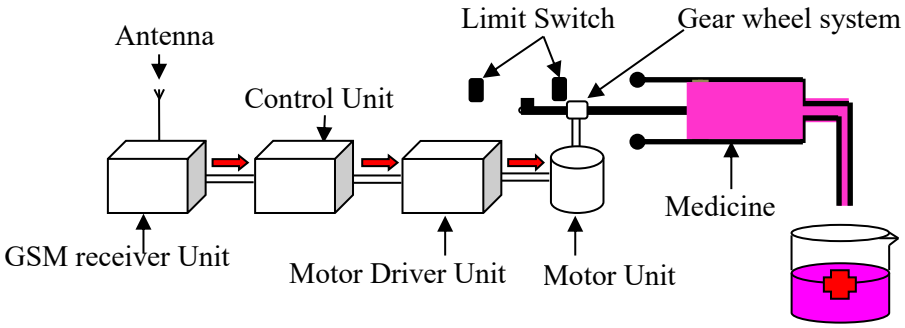

Figure 1: Block Diagramme of the Proposed system

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A calculation is carried out according to (1) and the motor driver unit rotates the stepper motor in the calculated speed and the calculated number of turns. This in turn dispenses the requested amount of liquid medicine in the requested rate. Note that the motor speed is constant, hence in order to control the dispense rate the rotations are carried out in discrete time intervals as shown in figure 3. By adjusting the time interval between adjacent dispense times, the dispense rate is varied.

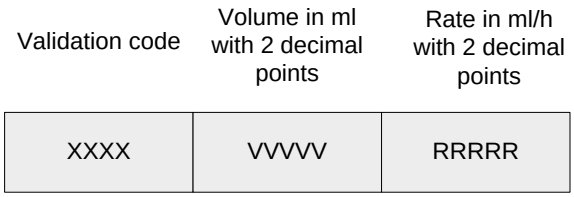

Figure 2: Short message structure

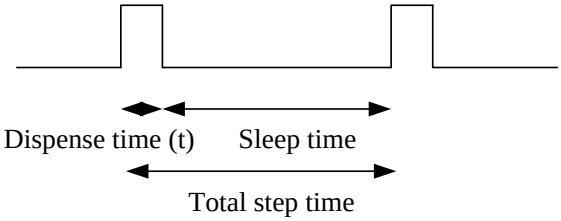

Figure 3: Dispense timing diagram

As shown in figure 4, with the motor rotations, a gear wheel system with a unit gear ratio transfers the rotations to a screwed shaft. A screwed barrel arrangement, through which the shaft passes, is linearly moved with shaft rotations. This linear movement is harnessed to move the syringe piston.

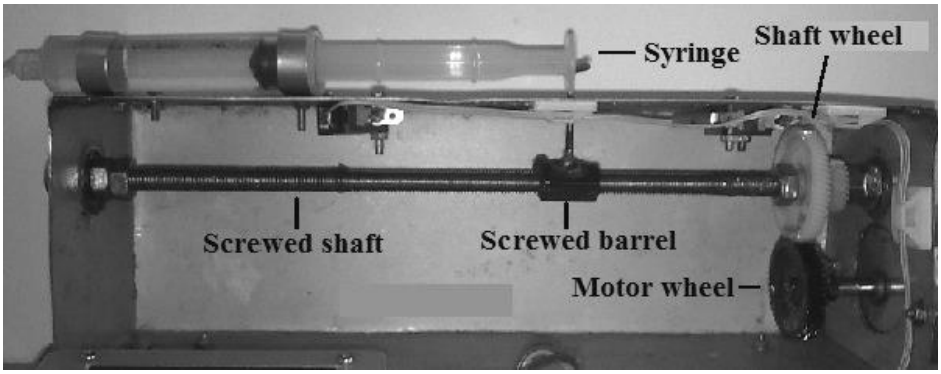

Figure 4: Mechanical unit of the proposed medicine dispenser

Let $\boldsymbol{V}$ volume is to be dispensed in $\boldsymbol{R}$ rate and a single step of the stepper motor dispenses $\boldsymbol{v}$ volume of liquid medicine. Then we need $\frac{\boldsymbol{V}}{\boldsymbol{v}}$ steps of rotation.

The total dispense time is $\boldsymbol{T} = \frac{\boldsymbol{V}}{\boldsymbol{R}}$ and the step time is $\frac{\boldsymbol{v}}{\boldsymbol{R}}$. With a dispense time $\boldsymbol{t}$, sleep time is,

$$\frac{v}{R} - t. \quad \text{.....(1)}$$

The constants v and t are to be obtained via trial tests for initial calibration.

Another added feature of this system is the ability to rotate the motor in the reverse direction such that the screwed barrel arrangement will move in the reverse direction which allows freeing the syringe from the system for cleaning and refilling.

RESULTS AND DISCUSSION

A prototype of the proposed medicine dispenser was designed and implemented and the tests revealed the v to be $0.0035ml$ and that the time t is negligibly small. Hence the sleep time can be assumed to be $\frac{v}{R}$. Further, a perfect and error free SMS framework was assumed which is a reasonable assumption in Sri Lankan mobile communication networks.

With this setup, the tests were carried out by short messaging different volumes and rates for medicine dispensing. The actual volume and the time spent for dispensing the same were recorded. The results shown in Table 1 clearly show the accuracy of medicine dispensing which is a key feature in this system. The maximum dispense volume error of 10% and a maximum dispense time error of 11.11% are within the acceptable error margins of most of the medicine dispensing requirements.

Although there no solid relationship between the errors in dispensed volume and the rate of dispense is seen, this system shows errors in dispensed volume less than 5% for the dispense rates below 60%.

Table 1: Comparison of the requested values and actually dispensed value

SMSed Values			Actual Values		Percentage Error (%)	
Rate (ml/H)	Volume (ml)	Corresponding Time (S)	Actual volume (ml)	Actual Time Taken (S)	In Volume	In Time
5	2	1440	2.04	1470	2	2.08
10	4	1440	4.05	1471	1.25	2.15
30	4	480	4.15	495	3.75	3.12
40	4	360	4.16	380	4	5.56
50	4	288	4.18	300	4.5	4.17
60	4	240	4.12	250	3	4.17
70	4	206	4.1	208	2.5	0.97
80	4	180	4.05	200	1.25	11.11
90	4	160	4.25	175	6.25	9.37
100	4	144	4.4	152	10	5.55
100	5	180	5.07	180	1.4	0
100	3	108	3.26	120	8.67	11.11
80	3	135	3.19	143	6.33	5.92
60	3	180	3.05	180	1.67	0
40	3	270	3.04	273	1.33	1.11
20	3	540	3.03	542	1	0.37
100	2	72	2.19	78	9.5	8.33
80	2	90	2	90	0	0
60	2	120	2.19	130	9.5	8.33
40	2	180	2.02	182	1	1.11

CONCLUSIONS AND FUTURE WORK

A remote medicine dispenser was proposed which is a handy tool to issue liquid medicine for a large number of patients in a short time. This is a very good solution for the shortage of trained nursing staff. This system can also be used to issue medicine from a far away location.

The same system can be further improved by incorporating a mechanism which allows the nurse or a doctor to query the available amount of medicine left in the syringe. Another possible feature is to detect the dispensed volume using a position sensor array fixed to the syringe's piston and to have a feedback message sent to the nurse confirming the dispensed volume. This would help the nurse to verify the functionality of the system. Furthermore, a software interface based short messaging system would further ease the nurse's job where a medicine dispensing can be automatically carried out with reference to a data base stored in a computer.

Further improvements in the system to limit the errors to a narrower margin would be an interesting research/design challenge.

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