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Original Article

Peripheral intravenous infusion for children based on computer digital video technology

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Abstract: Purpose: Intravenous infusion techniques often take a long time and require continuous monitoring of the infusion, and the needle must be removed promptly at the end of the injection, placing a burden on the patient, family and medical workers. Thus, this paper presents a droplet flow rate monitoring system based on an embedded system. Methods: In our retrospective study, according to different intervention measures, 80 patients were divided into two groups to compare the improvement of children's adverse psychological conditions. The patients were divided into control and intervention groups, with 40 patients in each group. Patients in the intervention group received psychological care and Online Real-Time Fusion Method to monitor the infusion state. Patients in the control group received routine infusions. Computer digital video technology and online real-time fusion algorithm were utilized to determine whether the parameters of the intravenous infusion model were optimized. The model's accuracy was used to evaluate whether the success rate of one-time needle insertion was improved. Results: The system can also be used for other monitoring. It is simple and convenient to set up and dismantle. The system can significantly relieve medical workers and patients. It was found that the observation group is significantly better than the control group in terms of psychological improvement ($P<0.05$). Comparing the patient's satisfaction, the difference between the two groups was statistically significant. Conclusion: When administering intravenous infusions in children, applying various forms of psychological interventions and giving emotional support can significantly improve their compliance and their mental state. It is of great significance to enhance the effect of infusions in patients.

Keywords: Computer digital video, children's intravenous infusion, popular science video, real-time fusion

Introduction

As a standard clinical method, intravenous infusion usually takes a long time [1]. The infusion condition needs to be continuously monitored, and the needle must be removed at the end of the injection, which are burdens patients, family members and medical workers [2]. Therefore, automatic infusion monitoring is needed in clinic [3]. Intravenous infusion formed a complete set of systems in the 20th century and has become one of the most effective, direct and commonly used clinical treatment methods [4, 5]. With the rapid development of digital integrated circuit technology, computer-related technology has been developed by leaps and bounds [6]. In practical applications, to realize intelligent control and a friendly man-machine interface, these microchips are often embedded and used in a specific system [7, 8].

So far, there is no noticeable gap in infusion monitoring technology between China and other countries, and new infusion automatic monitoring technology is being researched worldwide [9]. Currently, the automatic monitoring of infusion mainly adopts the following method, which can complete infusion detection, but there are still many shortcomings [10]. Koob [11] proposed a scheme that uses gravity (the change of weight during infusion), and the primary tool is a spring balance. According to the continuous decrease of weight during infusion, the spring balance gives feedback and alarms [12]. However, the practical applications are complex and changeable, such as a significant gap in the density of the liquid medicines [13], and the weight of the infusion bottle is not uniform. So the reliability during application is inferior, and the practicability is limited [14]. The main principle of the infusion method proposed by Koob is that as the liquid level decreases during infusion, the capacitance also changes during monitoring [15, 16]. The disadvantage is that it is also not suitable for complex and changeable situations in practical applications [17]. For example, the volume of different infusion bottles is not the same, so it is unsuitable for promotion [18].

With the development of computer, image processing and communication technologies, video surveillance technology has advanced significantly. Nathoo [19] analyzed that the earliest video surveillance system used copper or optical cables to transmit analogue signals to record and monitor. The leading equipment is monitors, video recorders, cameras and a video switching matrix. Milani [20] found that the earliest video surveillance system was mainly utilized for security or production workshop monitoring. Its advantages are easy to implement and low cost. Its disadvantages are limited distance, poor safety performance and single method [21].

This uses real-time signal processing on the video image of the infusion drip bucket to obtain real-time information. To effectively improve the patient's psychological status and treatment compliance, relevant psychological care measures can be applied when intravenous injection is given to patients. In this case, the success rate of infusion can be significantly improved, and the incidence of doctor-patient disputes can be reduced considerably.

Methods

Grouping and interventions

In our retrospective study, according to different intervention measures, 80 patients were divided into control and intervention groups to compare the improvement of anxiety levels after the intervention and patient satisfaction, with 40 patients in each group. Patients in the intervention group received psychological care and Online Real-Time Fusion Method to monitor the infusion state. Patients in the control group received regular infusions. This study has been approved by the Ethics Committee of Hunan Children's Hospital, China.

Computer digital video technology

The learning curve, also known as the experience curve, was proposed to describe the law of production efficiency changed over time. It was found that during the production process, as the cumulative output increases, the unit labour hours of the product will gradually decrease, and the production efficiency x[n] will increase progressively. Digital video real-time recording, first, is to acquire real-time images.

$$x[n] = \{x1, x2, \ldots, x(n)\}, (n = 1, 2, \ldots, i) \quad (1)$$

The second is to record real-time images. In short, it is to write the ideas into the memory, then read it from memory and report it to the hard disk. Because the storage speed D(x,y) is fast, and the hard disk's writing speed u(x,y) is limited, a hard disk must be used.

$$\frac{u(x,y) - R}{D(x,y)} = \begin{cases} 0, D(x,y) < R \\ 1, D(x,y) > R \end{cases} \quad (2)$$

If it is stored in field format, it needs to record x fields per second, and the processing time of each area is only y. If it collects and records one field each time, the time available for image recording is not more than field blanking. **Figure 1** shows the hierarchical distribution of computer digital video technology. The image acquisition card also supports another acquisition method. When the real-time acquisition function is executed, the acquisition card automatically writes the data into the frame memory in turn. There is no need to control, and f(m,n) can be used for image writing to the hard disk operation. In this way, real-time image collection can be achieved.

$$Med(x,y) = 1/2*[f(m,n/2) + f(m,(n+1)/2)] \quad (3)$$

At work, the computer's digital video playback program software controls the playing of popular science TV programs. The video signal N(x,y) is sent to a large-screen rear-projection TV through the display interface of the computer display card for demonstration. The TV has a computer display interface and can receive and display the computer monitor output signal g(x,y).

$$\sum_{f(x,y)<T} N(x,y) * f(x,y) = g(x,y) \quad (4)$$

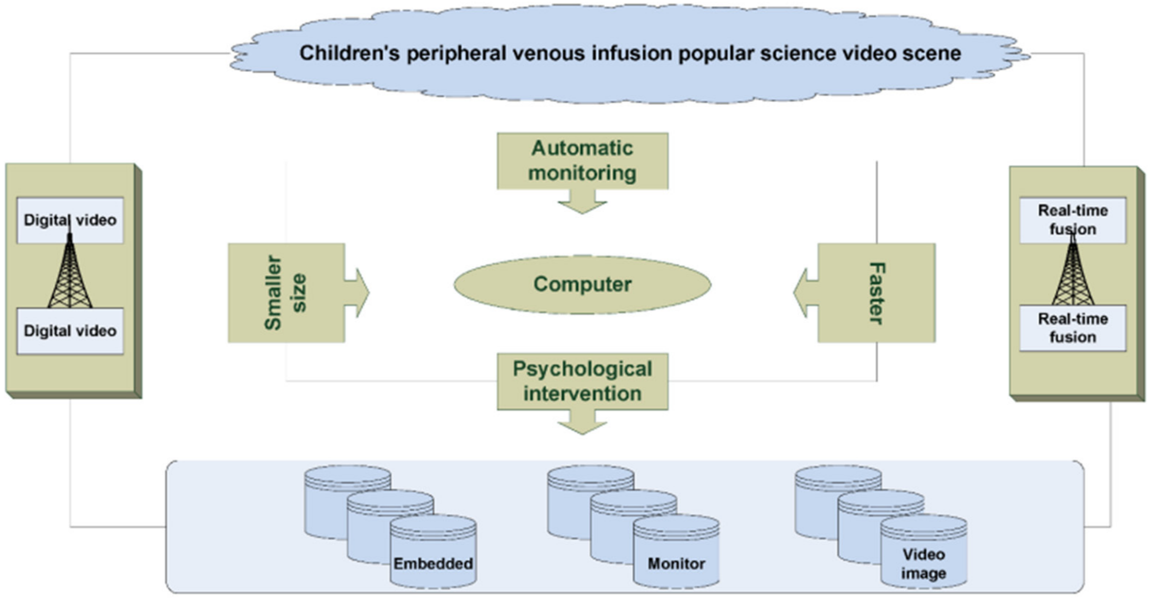

Figure 1. Hierarchical distribution of computer digital video technology.

During the playback process w(x) dx, the brightness and darkness N(x,y) of the main and auxiliary spotlights and the start and stop of weapon models should be adjusted according to to needs. After the playing of popular science the TV movie is finished, it will automatically restart from the beginning [22]. Using these powerful devices, users can write multimedia applications at different levels. Multimedia Control Interface (MCI) is a control method provided by Windows that can target each multimedia device and is independent of the device.

$$\int w(x) * dx = \frac{\sum_{g(x,y)<T} g(x,y)}{\sum_{f(x,y)<T} N(x,y)} \tag{5}$$

The most significant advantage of MCI is that the application system is irrelevant to the device. The corresponding Windows MCI Driver for standard multimedia devices can be installed, and Windows can operate and access the device. It can work for non-standard multimedia devices as long as the manufacturer provides MCI Driver.

$$A \oplus B = \{x \mid [B(x) \cup A] = \varnothing\} \tag{6}$$

Based on the independence of MCI and equipment, programmers can develop general multimedia application systems without requiring details of each product.

$$\begin{cases} R = 0.3a + 0.6b + 0.1c \\ S = -0.2a - 0.3b + 0.5c \\ T = 0.5a - 0.4b - 0.1c \end{cases} \tag{7}$$

Therefore, as long as the corresponding driver is installed in Windows, all applications can control them by calling MCI commands. The simplest method is calculating the absolute difference of adjacent images in the image sequence and then using a threshold for judgments.

The online real-time fusion algorithm

The image storage format can significantly affect the speed and quality of image recording. We chose to save the image as a binary file by frame. The recording speed and quality have reached the performance x(t) index requirements. When using this technology, the application will not directly change the content y(x) of the video memory used for display.

$$\int \frac{\partial y(x)}{\partial x} * \frac{\partial x(t)}{\partial t} dt = \int N(x,y)\,dxdy \tag{8}$$

On the contrary, it wants to change another area in the video memory. This area is called the back buffer. The content of the back buffer can be changed at any time, and then an entire back buffer can be put during the vertical

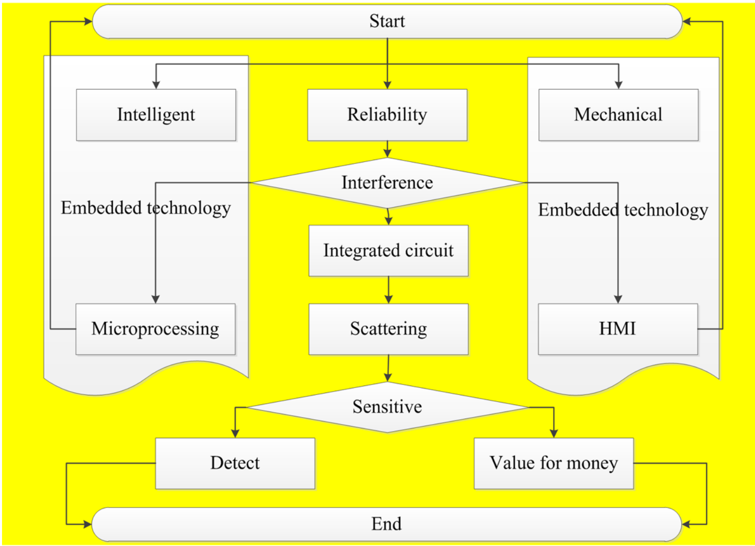

Figure 2. Online real-time fusion algorithm flow.

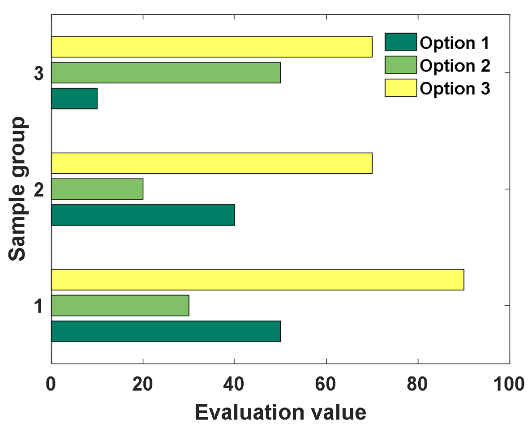

Figure 3. Histogram of evaluation values of different sample groups.

blanking interval. The switching operation usually changes a few registers on the display card.

$$\begin{bmatrix} z1 \ldots z(n) \end{bmatrix} * \begin{bmatrix} y1 \\ \cdots \\ y(n) \end{bmatrix} = \begin{bmatrix} w1 & 0 & 0 \\ 0 & \ldots & 0 \\ 0 & 0 & w(n) \end{bmatrix} \quad (9)$$

In this way, screen tearing can be fundamentally prevented. When the surveillance camera is still, the background image can be static or only slightly disturbed by default. The actual environment is much more complicated than the ideal situation. For example, the airflow causes a slight disturbance of the camera, and the illumination changes cause subtle changes in the image. **Figure 2** shows the online real-time fusion algorithm flow. When the requirements are not very precise, these subtle changes can be ignored, or preliminary processing can be performed through simple filtering.

The above program is a unique parameter structure for processing digital video files, which can replace the commonly used MCI parameter structure. Therefore, we can assign a timer to the media player when it starts, execute the above function at a specified time interval and query the number of video frames currently playing digital video.

After the injection is completed, the correct position of the dicing needle should be confirmed repeatedly when the blood is withdrawn. The liquid medicine should be fully discharged, and a reasonable pressure value should be set. **Figure 3** shows the histogram of the evaluation value of different sample groups. In addition to the LED indicator indicating the operational status of the power relay, a varistor is also connected to the terminal of the output relay. Once the controlled voltage exceeds the rated value, the resistor will fuse to protect the connected load from damage. In the system, the control requirements are relatively complicated and cannot be controlled with ready-made soft decompression media players. Therefore, a set of digital video playback software needs to be specially developed to meet the application requirements of this system.

Optimization of intravenous infusion model parameters

The Children's Pain Behavior Assessment Scale (FLACC) [23] was used to assess the children's pain from 5 aspects, facial expressions, body movements, activities, crying and comfortability, each using a 0-2 point scoring method. The total score is 10 points. The higher the score, the stronger the child's pain is. The self-made cooperation degree questionnaire was used to evaluate the cooperation degree of the two groups of family members during the treatment. According to the attitude and behavior of

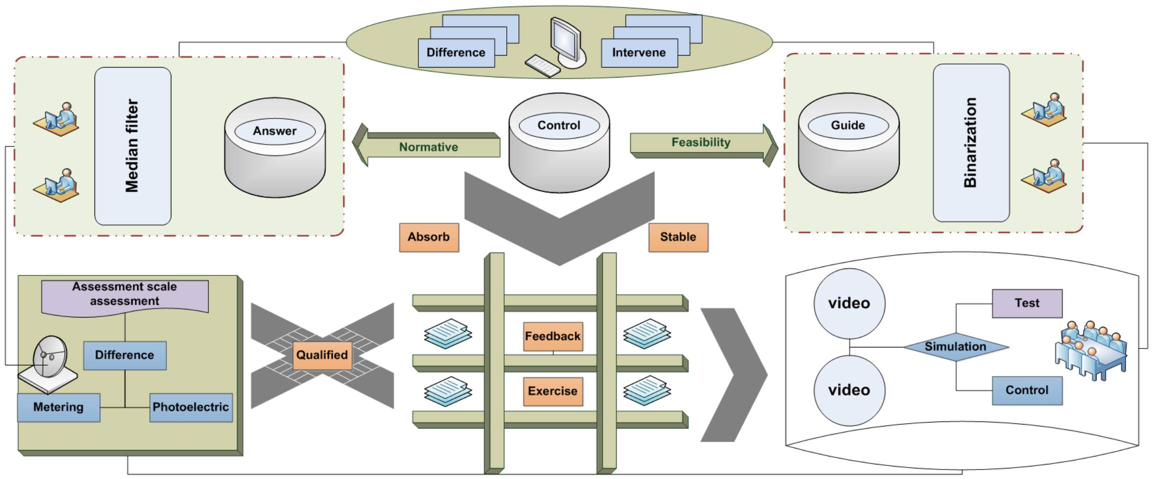

Figure 4. Online real-time fusion model framework based on computer digital video technology.

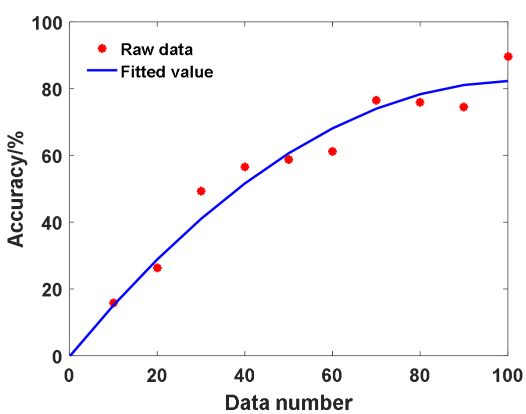

Figure 5. Fitting curve of model accuracy.

the family members, the degree of cooperation was divided into three levels: good, medium and poor. One family member of each child was selected as a representative, and the same nurse conducted the evaluation. **Figure 4** shows the online real-time fusion model framework based on computer digital video technology. Children's veins are thin and small, making it difficult to puncture. When the child have a strong resistance during puncture, the venipuncture may fail. Repeated puncture attempts not only increase the fear of the child but also reduce the comfort of treatment. The model's optimal time-saving ability uses preset (style sheets) to simplify the setting of critical options for output, compression and other tasks. At the same time, some basic knowledge related to image processing is introduced, and Matlab is used to verify the effect of the inter-frame difference in different situations to ensure the feasibility of the algorithm [24]. Meanwhile, the corresponding morphological processing is performed on the image to complete the regional positioning function.

The results of this study showed that the one-time puncture success rate of the intervention group was higher than that of the control group ($P<0.05$). The FLACC score of the intervention group was lower than that of the control group ($P<0.05$). **Figure 5** shows the fitting curve of model accuracy. Because nursing care focuses on easing children's emotion stresses and guiding good compliance behaviors, it reduces crying and physical resistance during punctures, thereby increasing the success rate of one-time puncture.

Results

Computer digital video feature extraction

After a comprehensive comparison, the OK64-10 development board based on the Samsung S3C6410 processor is selected. The external switching circuit uses Advantech's PCL-734 32-channel digital output card with optocoupler isolation and PCL-885 16-channel power relay board. The output circuit of PCL-734 is an open-collector gate output, which has a relatively large current drive capability, and its maximum sink current is 200 mA. The output voltage can be adjusted from 5 V to 40 V, and there is also a bleeder diode for inductive loads. The PCL-885 relay output card is aimed at high-power loads. There are 16 control channels in total, and the maximum load capacity of a sin-

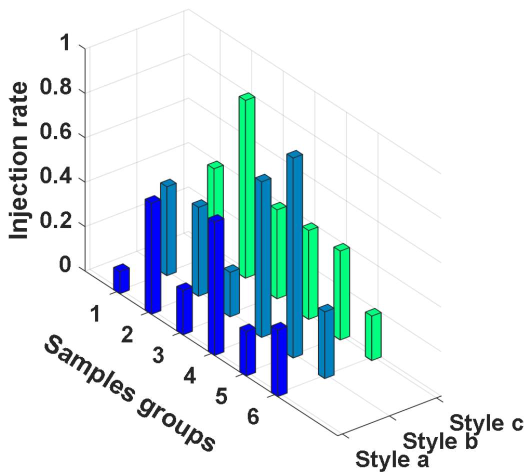

Figure 6. Three-dimensional histogram of infusion rate in different scenarios.

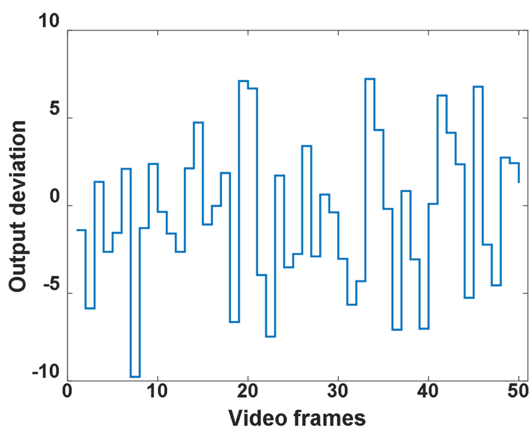

Figure 7. Ladder diagram of output deviation of different video frame numbers.

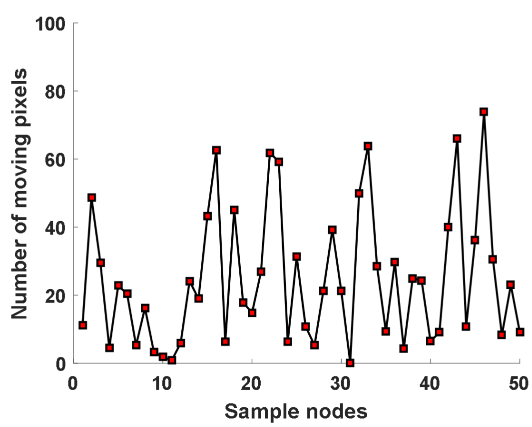

Figure 8. Line graph of video moving pixels changing with sample nodes.

gle channel is 250 V × 3 A, which can cope with various standard loads.

Figure 6 shows the three-dimensional histogram of the infusion rate in different scenarios. In the teaching and training, the in-hospital operation teacher recorded a video of intravenous infusion using secure techniques (referred to as the scoring standard).

Comparing the situation of each practice with the previous one, the average score of nursing students tends to be stable when the course reaches 14 times. During droplet formation, the moving pixels are tiny and easily disturbed. At this time, there are "double peaks" at 3 and 35 frames. In the specific detection, the "double peaks" with an interval of fewer than five frames only take the former, and the latter are all considered to be the same liquid level fluctuation.

The interval between the two prominent wave crests is the interval at which the droplet falls on the liquid surface. **Figure 7** shows the output deviation ladder diagram of different video frame numbers. The operation teacher demonstrated closed infusion for the nursing students on the spot and then distributes the operation video and scoring standards to the students. Then the students practice in groups according to the learning material under the guidance of the operation teacher.

Example application and analysis

The operation teacher is responsible for recording the time and frequency of each practice. While one person was practicing, the other members of the group watched and learnt according to the video and scoring standards. Nursing students passed the assessment after 24 exercises, and the average score of the nursing students stabilized from the 14th exercise. The time required for each movement of the nursing students stabilized after the 12th exercise, and all of them reached the pass standard. The minimum number of practice cases required for nurse trainees to master the technique of venipuncture infusion was 14 times (**Figure 8**). We adopted inspection, single-sample Kolmogorov-Smirnov test and SNK test for comparison. The inspection level was set as two-sided α=0.05. The whole process of playing health education videos took 30 minutes. **Figure 9** shows the two-dimensional scatter point distribution chart of video transmission rate at different time intervals. To facilitate patients' memory while ensuring the standard-

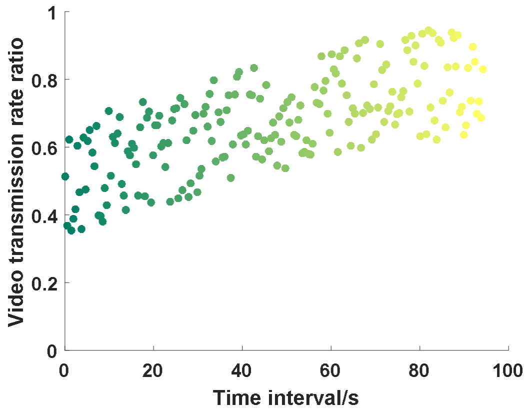

Figure 9. Two-dimensional scatter point distribution diagram of video transmission rate ratio at different time intervals.

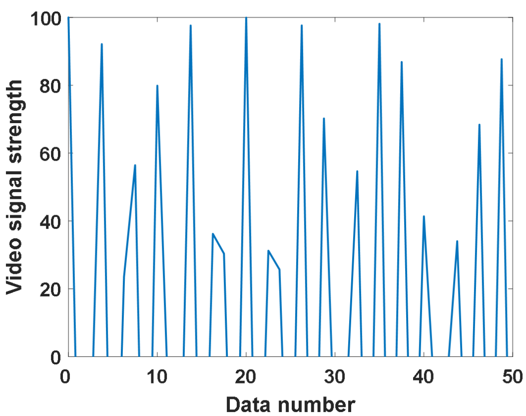

Figure 10. Dependence of video signal strength with data points.

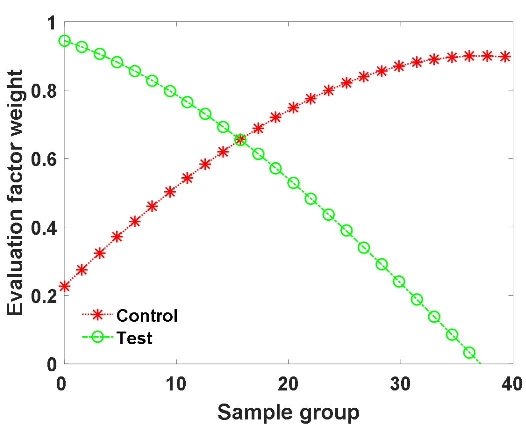

Figure 11. Comparison curve of model evaluation factor weights.

ization and feasibility of video health education, the videos were played for 30 minutes every day after the patients were hospitalized.

According to the steps of the inter-frame difference method, we first used the function to extract the image data of each frame from the recorded format videos. Then, the grayscale image data were processed by the inter-frame difference, and the median filter then the binarization were performed. This design uses a loop iteration method to select an appropriate threshold. For the convenience of analysis, connectivity analysis is not served here. The self-care ability scale was employed before and after the intervention to evaluate the patient's self-care ability. The evaluation aspects included self-care responsibility, skills, concepts and knowledge. There are 43 items on the scale, and all items were used, with a 5-level scoring method, a score of 0 to 4 points, and a full score of 172 points. **Figure 10** shows the dependence of video signal strength on data points. The stream interface driver is generally a dynamic link library, and the system loads the stream interface driver through the device manager. The stream interface driver communicates with the underlying device by calling the interface functions provided by the module.

A self-designed patient treatment compliance questionnaire was used to evaluate the treatment compliance. The scale included diet, daily activities, daily maintenance at the port of implantation, and prevention of adverse reactions. The questionnaire has 10 items with a 1-4-points scoring scale. A score over 30 points is seen as compliance.

Nursing students passed the assessment after 24 exercises. The average score of the nursing students stabilized from the 14th exercise; the time required for each exercise to be stable was after the 12th exercise, and all of them passed. In summary, when the requirements for the instantaneous velocity accuracy of each drop are not very high, as long as the liquid level is not close to the catheter, the frame-to-frame difference algorithm used in this paper can still meet its design needs. The results of this study showed that the degree of cooperation of the family members of the intervention group was higher than that of the control group ($P<0.05$); the rates of needle removal and leakage in the intervention group were lower than those of the control group ($P<0.05$) (**Figure 11**).

The traditional procedures of intravenous infusion are as follows: the nurse receives the patients' medication according to the doctor's advice and verifies the infusion information → hand-writes or prints the label of the infusion bag → dispenses the medicine and mix the liquid → checks the patient's information and the infusion before injection → changes the infusion when the patient asks for help → removes the needle after infusion. At the same time, frequent manual fluid change can cause pollution, error and other hidden risks. In view of the above problems, the automatic fluid change intravenous infusion device designed in this study has the following advantages:

1. It improves the effectiveness of intravenous infusion. The automatic liquid exchange system of the liquid allowance detection device can reduce the misjudgment by the naked eye, and avoid the waste of medication caused by changing the liquid too early [25].

2. It reduces the work load of medical workers. The application of the device can save the time of fluid change for medical workers to engage in other work and improve the overall quality of nursing work. Especially in the process of centralized infusion in hospital infusion room. By applying this device, the work efficiency can be obviously improved [26]. At the same time, automatic fluid change is realized during the whole infusion process, without the need for patients or family members to observe the progress of the fluid infusion and avoid calls during fluid change [27].

Conclusion

This article has completed the kernel customization and transplantation of the Windows 32 operating system. An in-depth analysis of three moving target detection algorithms and an inter-frame difference method were used to detect the infusion drip speed. Matlab is used to simulate the droplet velocity detection performance of the velocity measurement algorithm under different droplet velocities, different liquid level heights, and sloshing interference conditions. The threshold value is given through statistics. In addition, video-based health education is equipped with background music, pictures and animations to stimulate patients' learning enthusiasm and improve their disease management capabilities. This study showed that the disease knowledge awareness rate, treatment compliance rate, and patient satisfaction rate of the intervention group were higher than those of the control group, and the incidence of complications and adverse events was lower in the intervention group than those in the control group ($P<0.05$). In addition, a Windows 32 droplet velocity measurement program was written, which completed the location of the video image area, video image transcoding, inter-frame difference detection, alarms, and a man-machine interface. In summary, video-based health education can effectively improve the self-care ability, disease knowledge awareness rate, and treatment compliance of patients with fully implantable infusion ports, reduce the incidence of patient-related complications, and improve patient satisfaction.

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Disclosure of conflict of interest

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References

[1] Moritz ML, Ayus JC and Nelson JB. Administration of 3% sodium chloride and local infusion reactions. Children (Basel) 2022; 9: 1245.

[2] Mak WY, Yuen V, Irwin M and Hui T. Pharmacotherapy for acute pain in children: current practice and recent advances. Expert Opin Pharmacother 2011; 12: 865-881.

[3] Zhang L, Berzins V and Qiao Y. Documentation driven development for complex real-time systems. IEEE Transactions on Software Engineering 2004; 30: 936-952.

[4] Oo YH, Ackrill S, Cole R, Jenkins L, Anderson P, Jeffery HC, Jones N, Jeffery LE, Lutz P, Wawman RE, Athwal AK, Thompson J, Gray J, Guo K, Barton D, Hirschfield GM, Wong T, Guest P and Adams DH. Liver homing of clinical grade Tregs after therapeutic infusion in patients with autoimmune hepatitis. JHEP Rep 2019; 1: 286-296.

[5] Nørgaard-Pedersen C, Nielsen K, Steffensen R, Eriksen L, Jørgensen MM, Kesmodel US and Christiansen OB. Intravenous immunoglobulin and prednisolone to women with unexplained recurrent pregnancy loss after assisted reproductive technology treatment: a protocol for a randomised, double-blind, placebo-controlled trial. BMJ Open 2022; 12: e064780.

[6] Salama ER and El Amrousy D. GlideScope (R) cobalt video laryngoscope versus direct Miller laryngoscope for lateral position-tracheal intubation in neonates with myelodysplasia: a prospective randomized study. Saudi J Anaesth 2019; 13: 28-34.

[7] Tejero Rioseras A, Garcia Gomez D, Ebert BE, Blank LM, Ibanez AJ and Sinues PM. Comprehensive real-time analysis of the yeast volatilome. Sci Rep 2017; 7: 14236.

[8] Ni ZK, Lin D, Wang ZQ, Jin HM, Li XW, Li Y and Huang H. Precision liver resection: three-dimensional reconstruction combined with fluorescence laparoscopic imaging. Surg Innov 2021; 28: 71-78.

[9] Hoskins SL, Elgjo GI, Lu J, Ying H, Grady JJ, Herndon DN and Kramer GC. Closed-loop resuscitation of burn shock. J Burn Care Res 2006; 27: 377-385.

[10] Rive CM, Yung E, Dreolini L, Brown SD, May CG, Woodsworth DJ and Holt RA. Selective B cell depletion upon intravenous infusion of replication-incompetent anti-CD19 CAR lentivirus. Mol Ther Methods Clin Dev 2022; 26: 4-14.

[11] Koob AO, Duerstock BS, Babbs CF, Sun Y and Borgens RB. Intravenous polyethylene glycol inhibits the loss of cerebral cells after brain injury. J Neurotrauma 2005; 22: 1092-1111.

[12] Santos-Costa P, Alves M, Sousa C, Sousa LB, Paiva-Santos F, Bernardes RA, Ventura F, Salgueiro-Oliveira A, Parreira P, Vieira M and Graveto J. Nurses' involvement in the development and usability assessment of an innovative peripheral intravenous catheterisation pack: a mix-method study. Int J Environ Res Public Health 2022; 19: 11130.

[13] Shao G, Zhou X, Zhang S, Wu S, Dong Y and Dong Z. Cost-utility analysis of centrally inserted totally implanted access port (PORT) vs. peripherally inserted central catheter (PICC) in the oncology chemotherapy. Front Public Health 2022; 10: 942175.

[14] Le Guen M, Liu N, Tounou F, Auge M, Tuil O, Chazot T, Dardelle D, Laloe PA, Bonnet F, Sessler DI and Fischler M. Dexmedetomidine reduces propofol and remifentanil requirements during bispectral index-guided closed-loop anesthesia: a double-blind, placebo-controlled trial. Anesth Analg 2014; 118: 946-955.

[15] Bhave SY. Computer programmes in pediatrics. Indian Pediatr 1992; 29: 245-253.

[16] Sampson JH, Raghavan R, Brady ML, Provenzale JM, Herndon JE 2nd, Croteau D, Friedman AH, Reardon DA, Coleman RE, Wong T, Bigner DD, Pastan I, Rodriguez-Ponce MI, Tanner P, Puri R and Pedain C. Clinical utility of a patient-specific algorithm for simulating intracerebral drug infusions. Neuro Oncol 2007; 9: 343-353.

[17] Žunkovič M, Markota A and Lešnik A. Attitudes towards the utilization of intraosseous access in prehospital and emergency medicine nursing personnel. Medicina (Kaunas) 2022; 58: 1086.

[18] Sheng Y, Wu T, Fan C, Hao H and Gao W. Factors influencing the optimal selection of central venous access devices: a qualitative study of health care team members' perspectives. Int J Nurs Sci 2022; 9: 445-452.

[19] Nathoo N, Cavuşoğlu MC, Vogelbaum MA and Barnett GH. In touch with robotics: neurosurgery for the future. Neurosurgery 2005; 56: 421-433; discussion 421-433.

[20] Milani M, Annoni A, Moalli F, Liu T, Cesana D, Calabria A, Bartolaccini S, Biffi M, Russo F, Visigalli I, Raimondi A, Patarroyo-White S, Drager D, Cristofori P, Ayuso E, Montini E, Peters R, Iannacone M, Cantore A and Naldini L. Phagocytosis-shielded lentiviral vectors improve liver gene therapy in nonhuman primates. Sci Transl Med 2019; 11: eaav7325.

[21] Wierwille J, Andrews PM, Onozato ML, Jiang J, Cable A and Chen Y. In vivo, label-free, three-dimensional quantitative imaging of kidney microcirculation using Doppler optical coherence tomography. Lab Invest 2011; 91: 1596-1604.

[22] Horvat S, Staffhorst B and Cobben JMG. Intravenous lidocaine for treatment of chronic pain: a retrospective cohort study. J Pain Res 2022; 15: 3459-3467.

[23] Kamel AAF, Medhat MM, Salem DAE and Naby SMA. Effect of perioperative magnesium sulfate and labetalol infusion on peripheral perfusion and postoperative pain in nasal surgery: a randomized controlled trial. Patient Saf Surg 2022; 16: 27.

[24] Lee CK, Chon HJ, Cheon J, Lee MA, Im HS, Jang JS, Kim MH, Park S, Kang B, Hong M, Kim JW, Park HS, Kang MJ, Park YN and Choi HJ. Trastuzumab plus FOLFOX for HER2-positive biliary tract cancer refractory to gemcitabine and cisplatin: a multi-institutional phase 2 trial of the Korean Cancer Study Group (KCSG-HB19-14). Lancet Gastroenterol Hepatol 2022; [Epub ahead of print].

[25] Ben Shabat I, Ben Shabat MH, Ben Abraham S, Sagy I, Tsaban G, Cohen-Lahav M, Goldinger G, Peled M and Bartal C. Reliability of blood tests taken from the peripheral intravenous catheter. Medicine (Baltimore) 2022; 101: e29268.

[26] Doyle BJ, Kelsey LJ, Shelverton C, Abbate G, Ainola C, Sato N, Livingstone S, Bouquet M, Passmore MR, Wilson ES, Colombo S, Sato K, Liu K, Heinsar S, Wildi K, Carr PJ, Suen J, Fraser J, Li Bassi G and Keogh S. Design, development and preliminary assessment in a porcine model of a novel peripheral intravenous catheter aimed at reducing early failure rates. J Vasc Access 2022; 11297298221127760.

[27] Bjerre-Bastos JJ, Sejersen C, Bihlet AR, Secher NH, Mackey AL, Kitchen CC, Drobinski P, Thudium CS and Nielsen HB. An estimate of plasma volume changes following moderate-high intensity running and cycling exercise and adrenaline infusion. Front Physiol 2022; 13: 948087.