Market Research and Design of a New Dental Medical Vehicle Based on Digital Technology

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Abstract. Aiming at the problem that oral hygiene is often overlooked and oral treatment is often convenient, this article proposes a new type of oral medical vehicle based on digital technology. The article starts with the application range of the dental medical vehicle, clarifies the necessity of the design research, and introduces the structure and key technologies of the currently designed medical vehicle, and then introduces the working mode of the medical vehicle and the optimal path algorithm carried. Finally, based on market surveys, it is concluded that dental medical vehicles will definitely attract more people's attention in the future, and their market demand will increase.

1. Preface
The application of dental medical vehicles is a more popular development situation in the world for universal dental prevention and treatment. With the improvement of people's living standards, people are paying more and more attention to oral hygiene and dental health. At the same time, China's medical security system and health system are gradually improving. More and more attention is paid to community medical care, but dental hospitals and dental clinics will not be in front of every house. Therefore, dental medical carts are proposed as a solution, which is reasonable, simple, and efficient. It is recognized that the market demand for dental medical vehicles will increase in the foreseeable future.

2. Application range of dental medical vehicle
2.1. The application of dental medical vehicles in cities
The main purpose of the dental medical vehicle is to allow patients to receive routine oral diagnosis and treatment without leaving home. Conventional dental diagnosis and treatment services can be carried out in dental medical vehicles. Therefore, the main application areas of dental medical vehicles are nursing homes, elderly apartments, elderly communities far away from dental hospitals, kindergartens, and elementary schools. The main users are the elderly and children. Or other people with limited mobility. For the elderly or people with limited mobility, when there is a problem with their oral health, the problem is often ignored due to the distance between the dental hospital or clinic. When minor illnesses become serious or the pain is unbearable, they will choose to seek medical treatment. And because of its convenience, dental medical vehicles can perform oral examinations at any time when there is a problem with their oral hygiene, instead of going to a fixed place for medical treatment. For children, because their eating habits may have problems, regular oral examinations are required.
However, a large number of children flock to the hospital, which also places a certain burden on the medical system. Therefore, it is a better solution to allow dental medical vehicles to enter the campus.

2.2. The application of dental medical vehicles in rural areas

Difficulty in seeing a doctor in rural areas has always been a key concern of the society and a problem that the country needs to solve urgently. The health problems of farmers and herders, especially oral health problems, are often overlooked due to objective reasons. On the one hand, in remote mountainous areas, fixed medical clinics are set up because of the sparse population. There is usually a problem of low utilization rate and waste of medical resources. On the one hand, because farmers’ income is relatively low, “tolerate minor illnesses and endure serious illnesses” is often the main “medical” method chosen by farmers. In order to solve the oral health problems of people in rural areas and remote areas, the use of dental medical vehicles is a very affordable method. As a mobile "clinic", the dental medical vehicle has guaranteed the utilization rate of medical resources, and since the cost of the "clinic" is only the cost of medical equipment, the treatment price can also be relatively low, which is more suitable for solving farmers' problems. Oral health problems.

3. The structure and key technology of dental medical vehicle

The specifications of the currently designed dental medical vehicle are 5780*1998*2552 (total length*total width*total height), and the rated number of passengers for the vehicle is 2-9. The car is equipped with professional dental medical equipment such as a comprehensive dental treatment table, a dental prosthesis instrument, an oral endoscope, a dedicated intraoral scanner for dentures, a dedicated intraoral scanner for dental implants and a mobile computer. At the same time, there are three internal systems in the car: gas circuit, water circuit, and electric circuit, so that the temperature and power supply in the car can be kept normal, and the sewage generated by the treatment can be treated. The structure design of the dental medical vehicle is shown in Figure 1.

![Figure 1 Conceptual diagram inside the car](image)

3.1. Intraoral scanning system

3.1.1. Intraoral camera

The intraoral camera is a camera with a special structure, which can be inserted into the oral cavity to take pictures of teeth and other tissues under the illumination of its own light source, and display the captured content on the computer screen. The patient can be recorded through the intraoral camera Oral details, provide detailed information for oral medical programs.

3.1.2. Intraoral scanning rods for dental implants

The implant-specific intraoral scanning rod is used for the intraoral scanner to obtain the projection of the dental model and accurately reflect the implant position data. Do not spray powder during operation and avoid errors. At the same time, the scanning bar can be operated fully digital, which makes the data more accurate and convenient to use. The intraoral scanning rod has the characteristics of unique assembly direction, high processing accuracy, high visualization and reusability.
3.2. Light-curing resin for planting model printing

The light-curing resin is composed of a prepolymer and a resin monomer, containing active functional groups, and can be polymerized by a photosensitizer under ultraviolet irradiation. The polymerization process is shown in Figure 2.

Figure 2 Photocurable resin polymerization process

Light-curing resin is a commonly used repair and filling material in dentistry. Because of its beautiful color and certain compressive strength, it plays an important role in clinical applications. The technical parameters of the products we use are shown in Figure 3.

3.3. 3D printing technology of dental model

The technical concept of masked stereo lithography technology was proposed as early as 1992. Its principle is to cure one layer of photosensitive resin at a time by means of masked projection, and obtain a stereo model through accumulation of layers. Compared with the three-dimensional lithography technology scanned by dots, lines and surfaces, its forming speed is faster, the surface quality of the parts is higher, and the forming effect is better for printed workpieces with finer details. With the application of spatial light modulator technologies such as LCOS, LCD, and DMD, mask stereolithography technology has become a rapidly developing process and is widely used. Figure 4 shows the working principle of the masked stereo lithography technology.
3.3.1. Special printer for dental model. The special printer for dental models uses intelligent software and cooperates with different independent research and development materials to realize wax crowns (single crowns, pontics, half teeth, stents, etc. can be embedded casting models) and restoration models (dental models, substitutes), Upper and lower jaw, etc.) printing work. The printer prints out a high-reducibility dental model based on accurate data to assist doctors in treatment, and to the greatest extent avoids the problem of deviations in hand-made dental products and delays in treatment progress. The product schematic diagram of the printer is shown in Figure 5.

3.3.2. Dental model design software. The special dental model design software is a set of software system for scientific management of dental processing and manufacturing industry. This software integrates functions such as denture order management, delivery reminder, order search, rework registration, system maintenance, etc., which can realize real-time monitoring and management of production processes and daily affairs. The software is easy to use. The denture data can be collected and shared through the network. By sharing the coordinate system with the 3D model printer, the whole process of scanning and printing the denture can be systematized. At the same time, it can output the coordinate system in the specified format to manually perform the model. Adjust to make the printed denture model more practical.

4. The outpatient process and optimal path algorithm of dental medical vehicle

4.1. The outpatient process of dental medical vehicle
First, the customer uses the network communication equipment to place an order to the dental medical vehicle headquarters, upload the demand, provide its own positioning, and then upload the positioning to the cloud server. The cloud server converts the positioning into coordinate points and sends it to the path planning software. The path planning software calculates the best Path, and then the dental medical vehicle makes outpatient visits according to the best path to ensure that the shortest time is used to provide services to the most users. At the same time, during the visit, there will be new orders and
demands at any time, and the path planning will be updated at any time, forming a closed loop of the procedure. The outpatient flow chart is shown in Figure 6.

![Outpatient Flow Chart](image)

**Figure 6** The outpatient process of dental diagnosis and treatment vehicle

4.2. **Best path algorithm**

The best path algorithm used in this research design is ant colony algorithm. The research model of the ant colony algorithm is derived from the simulation of the foraging behavior of ants. When ants foraging, they will release a volatile pheromone. Different ants plan their foraging direction by sensing the intensity of this pheromone. Ants will choose a path with higher pheromone intensity as their foraging path, thus forming a positive feedback mechanism, that is, the closer the path, the greater the pheromone intensity, the pheromone of the remaining paths will gradually volatilize, and finally the entire ant colony Search for the best path.

The ant colony algorithm draws on the foraging behavior in nature. Suppose m ants are placed in n random communities, C is the community set, \( \tau_{ij}(t) \) represents the amount of information on the paths of communities i and j at time t, and \( \eta_{ij} \) is a heuristic factor, which means that ants move from community i to community i at time t. The expected journey of community j. Usually \( \eta_{ij} \) is the reciprocal of the distance between communities.

State transition probability criterion. Each ant independently selects the next community to be transferred based on the amount of pheromone in each path, and records the community that ant k has walked through in \( \text{tab}_k \). At time t, the state transition probability \( p_{ij}^k(t) \) of ant k moving from community i to community j is shown in equation (1).

\[
p_{ij}^k(t) = \begin{cases} \frac{\text{allowed}_k = \{C - \text{tab}_k\}}{\sum_{s \in \text{allowed}} [\tau_{is}(t)]^a \eta_{is}^\beta} & \text{if } j \in \text{allowed}_k \\ 0 & \text{otherwise} \end{cases}
\]

In the formula, \( a \) is the information heuristic factor, reflecting the influence of pheromone on the path chosen by the ant, \( \beta \) is the expected heuristic factor, indicating the influence of the path length on the ant, and \( \text{allowed}_k \) is the choice when the ant moves next Collection of communities.

Pheromone update. After all ants have completed a traversal, the remaining pheromone on the path is updated, and the pheromone on each path is adjusted according to formula (2).
\[
\begin{align*}
\tau_{ij}(t + n) &= (1 - \rho) \cdot \tau_{ij}(t) + \Delta \tau_{ij}(t) \\
\Delta \tau_{ij}(t) &= \sum_{k=1}^{m} \Delta \tau_{ij}^k(t)
\end{align*}
\] (2)

In the formula, \( \rho \) is the volatilization coefficient, which reflects the persistence of pheromone. The value of \( \rho \) is between 0 and 1. \( \Delta \tau_{ij}(t) \) represents the increase of pheromone on the path \((i, j)\) after this cycle. \( \Delta \tau_{ij}^k(t) \) represents the amount of pheromone left by the \( k \)th ant on the path \((i, j)\).

\[
\Delta \tau_{ij}^k(t) = \begin{cases} Q/L_k, & \text{if the } k \text{th ant passes } (i, j) \text{ in this cycle} \\ 0, & \text{others} \end{cases}
\] (3)

In the formula, \( L_k \) is the sum of the distance traveled by the \( k \)-th ant in this cycle, and \( Q \) is the total amount of pheromone released by the ant after completing a path search. The model uses all the information after the ants complete a cycle to update the pheromone on the path.

5. Conclusions
With the development of the economy and the people's gradual attention to oral health, the research and design of dental diagnosis and treatment vehicles will gradually attract people's attention, and the market for oral hygiene will become larger and larger in the future. At present, many medical vehicles and medical examination vehicles in China are modified from passenger cars with their seats removed. There are very few mobile medical vehicles designed for medical treatment. The hidden risks and hidden dangers are unknown. What medical needs is Rigorous, medical equipment must not be sloppy. It is imperative to design special medical vehicles for life and health. Only by continuously developing multifunctional, practical and humanized products, and increasing its high-tech content new medical vehicles can meet the current needs of my country's medical industry.

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