

## CAID Research Based on Design Project of Rehabilitation Medical Robot

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**Abstract.** Belonging to a "973" National Science Research Plan of China, the upper limb rehabilitation medical robot design project, this paper research summarizes some main characteristics of a CAID (Computer Aid Industrial Design) design process, and mainly focuses on exploration of key technologies which transform Alias surface model into real entity model through UG, including researches of certain associated Alias surface parameters, as well as the qualitative variables relationships between Alias surface continuity level and its surface parameters.

### Introduction

Throughout the development time of medical rehabilitation robotics from the perspective of design disciplines, it's obviously to see that design disciplines involves in the development as a link-band between technologies and medical rehabilitation robot products. Not only it expedites the implementation process of the robot technologies stepping out the laboratory to mass production market, but also affects the final form and function presented in front of the user. Today, the growth of digital information technologies is explosive, the limitations of traditional design methods and processes is becoming increasingly apparent, while CAID design science is continuing penetrating in the field of industrial design. The CAID design methods in recent years, such as Autodesk Alias Design (Alias design solution), are playing a huge role in promoting reform to the industrial design process.

### CAID design theories based on design process

As we all know, standing on modern product design perspective, the traditional product design process is a two-way convergence order for both the quantity and quality according to a creative process. In a design team, a certain member put divergent proposals of creative solutions into assessment at a certain period of design process, after many iterations, the evolution convergences into an optimal objective results.

#### Transition of traditional design method

A traditional design process can be roughly divided into four stages based on this convergence property. The first stage is the creative development stage, the designer presented a variety of different design idea in depth. The second stage is the design evolution phases, during the first phase of the program, a more feasible proposal selected at this phase, and then, designers work with engineers to study the details and the structures inside the product with three to five product simulations. The third stage is the three-dimensional model building stage, after the engineer finishes Engineering drawing, the production staff produced a prototype model. The fourth stage is a manufacturing phase, it generally referred to various designs, including agencies, mold, painting, assembling, etc. until the product is put into mass production so far.

However, in the industrial area of consumer product, its design cycle becoming shorter, CAID design features has become increasingly evident throughout our design work . CAID design theory and technology along with the rapid development of digital information involve into the field of industrial design, expands the study scope of modern product design greatly. Belonging to a "973" National Science Research Plan of China, This medical rehabilitation robot program distinctively features CAID design methods. The design process can be broadly summarized as the model shown in fig.1, according to the achievement deriving from this project. It can be seen that the convergent design process shows clear iteration features under the guidance of ideas that based on CAID theory.

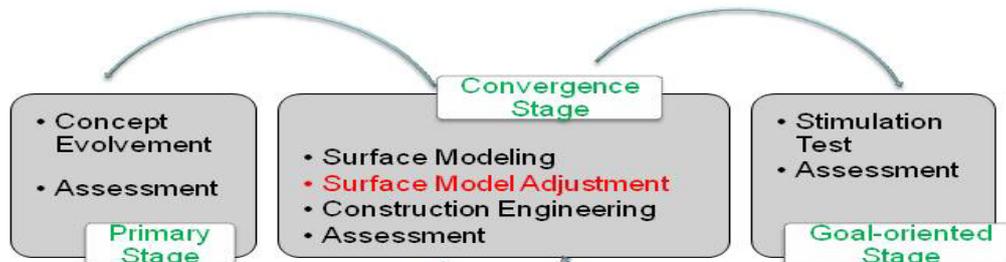


Figure 1. Design process of the project

### Specific influences derived from CAID technology applied in the project

CAID design ideas and methods bring not only shorten product development cycles, but also a reduced development costs, it affects the practical design at multiple levels of both theory practice. Based on the robotics research project results, four features as with the core of design process are summarized here(fig.2) :

(1) The conceptual design phase tends to be "paperless"

The CAID design process does not require a wide range of traditional sketching like tools, foot-print, regulations, pens, papers, etc. Autodesk Alias Design CAID design platform provides a wide virtual space for robot design, the traditional cumbersome design process transfers into a real-time interactive operational sketching communication.

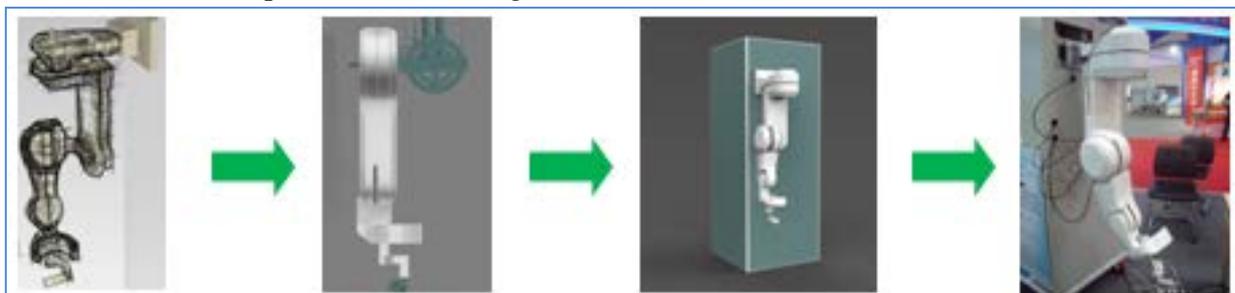


Figure 2. Process from sketch to prototype

(2) Convenient exchange of design proposal

Autodesk Alias Design platform has shortened the distance among each design roles from the angle of design process, avoiding repeated adjustment of design result. Comparing to traditional design process, it achieves remote collaborative design and appliance of design resources, maximizing the efficiency and quality of design.

(3) Flexible and efficient overall design throughout the program

CAID modeling creates solutions for medical rehabilitation robot arm, which can be built by fast 3D modeling & rendering. The overall form, shape adjustment, color, texture and other aspects of the assessment can be adjusted flexibly in time and place, which result in losing original position for traditional design methods. Compared with the traditional design process, it has made significant changes in focusing on the design development cycle.

(4) True and reliable design results

Based on virtual reality technology, Alias CAID has assessment capabilities beyond the design cycle. In order to test the upper-limb rehabilitation robot prototype, performance and real-time

interference are put into virtual reality simulation based on robot motion, which could greatly shrink the time of development cycle, as well as the research investment risks.

### Materialized operating of Alias surface in CAID design practice

Alias CAID design technology leads to an accelerated design efficiency and reduced costs for our design project, which is concluded from the angle of the design iteration characteristic . In addition, the intrinsic relevance between Alias surface parameters and the surface substantiation has also been explored, which reaches several conclusions by analyzing project data.

These data sources mainly embodies in the goal-oriented design process, "Surface model adjustment". At this stage, the UG entity data is generated through Alias Surface data, ultimately the robot prototype is printed out by 3D printing technology. As an upstream surface design software for UG, seamless coordination between Alias Surface data and UG entity data file is a crucial key to ensure the operation that realizes surface substantiation. The crucial surface modeling data in design process present significant feature of practical CAID theory, which is also what this paper focus to explore based on this project design issues.

#### Alias surface parameters processing and its substantiation operation

According to this practical operating experience of robot design project, a key element that influences the " Surface model adjustment " phase is the operational Alias surface phase, its success lies in achieving Alias proper upstream data files, as the Tran-conductance between Alias Surface data and UG entity data is a overall dominant operation, in this particular design phase of the project, certain core parameters of which are discussed here.

#### A. Computer graphology relevance between Alias Surface data and UG entity data

First of all, in the phase of "Surface model adjustment", the robotics styling surfaces are built by Alias NURBS modeling technology, which has capabilities to create curved shape of the robot quickly. See as the component surface part of the upper limb (fig.3).

Using Alias surface data to directly generate upstream entity data can greatly improve efficiency of iteration cycle, thereby shortening the design development cycle of the upper-limb rehabilitation medical robot. However, converting CAID surface data directly to UG entities file has a basic quality requirements, namely the surface continuity of the robot style surfaces has to reach at least G1 continuity (T continuity) quality level.

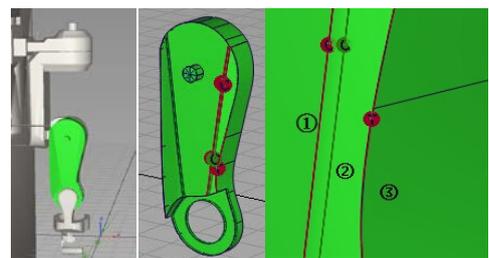
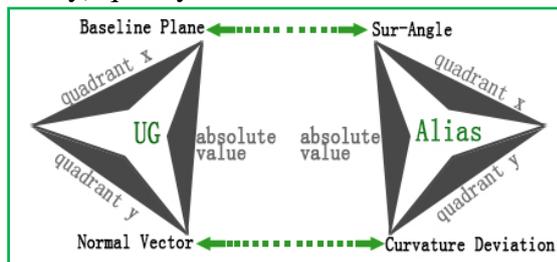


Figure 3.Surface part

Figure 4.The mapping feature

Figure 5.The marked surface positions

We found that Alias Surface data is lack of engineering constraints as well as necessary geometrical data because of its nurbs modeling graphology characteristics. UG' s materialized operation needs at least a baseline plane, a normal vector and an absolute value of the normal vector. These three basic parameters therefore can only be mapped by Alias surface parameters. The mapping relationship of which shows as fig.4. As seen from fig.6, the surface vector angle (Sur-Angle) and the surface curvature deviation (Curvature Deviation) of Alias surface's parameter respectively maps the baseline plane and the normal vector. Consequently, we can conclude that the G1 surface continuity requirement raised by entity operation is centralized on two surface parameters, which are embodied in Alias surface data as Sur-angle and Curvature Deviation.

#### B. Parametric correlation of Alias surface's continuity level

Following the conclusion above, the robotics materialized operating is achieved by Alias surface quality, surface vector angle (Sur-Angle) and the normal deviation (Curvature Deviation) maps two basic values materialized operating data. Therefore, studying the parametric correlation of these two parameters is highly significant toward overall design realization. In this goal-oriented design process, the variable relationship between materialized operating and these two surface parameters is explored qualitatively.

As shown in fig.5, three positions are marked continuity level with: (1) -G1 continuous, (2)-G2 continuous, (3)-G0 continuous, where the surface parameters of these three positions are used to explore variable relationship (Fig. 8 at the upper arm position (1)normal deviation angle, arm position (3) at 9 parameters).

Table 1 records three groups of extremes parameters data collected from these three positions above, we can summarize the qualitative variable relationship as follows: given a certain tolerance with UG modeling module, the Alias surfaces' Sur-Angle and Curvature Deviation values infinitely tend to 0 with a raising continuity level, and these values show a rang of linear discrete distribution feature.

Table 1. Key data table collected from the robot arm surface (unit.: deg & mm)

	G0 continuity	G1 continuity	G2 continuity
Sur-Angle	72.067min, 76.268max	0.000min, 0.000max	0.000min, 0.044max
Curvature Deviation	0.732min, 0.996max	0.009min, 1.000max	0.001min, 0.009max

Due to the direct connection between surface continuity level and Alias Surface materialized operating, this conclusion will affect the application of CAID theory to some degree. More importantly, it lays some practical basis for in-depth study on Alias CAID, and enhances this particular medical robotics design project's achievement.

## Summary

Computer information technology in our production and life has already become a main theme in this era, as a direct participant in industrial design field, we have to treat design features and attributes of CAID as a future design solution. Based on a design project of this emerging technology-intensive products - upper limb rehabilitation medical robotics, we summed up several actual practical outcomes standing at the aspects of methodological Alias design theory. Focusing on exploring the Parametric correlation of Alias surface's continuity level and its materialized operating, we hope that the inherent CAID conclusion may opens a view to the future's design practice and acts as paving stones for CAID design theory.

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