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A Robotic Device design for safety Guidance to Nursing Care

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Abstract - Using a physical helper robot might possibly enhance the quality of life for those who use it. Because of this, in the worst-case scenario, physical helper robots are utilised instead of standard industrial robots and machinery. The physical assistance robot will be developed with the help of a safety document. Using the "V-model," which includes concept design, risk assessment, safety validation, and user testing as the foundation, this advice establishes the core idea. This is how we're going to make things more secure and easier to use. It was for this reason that we devised a danger scenario for the physical helper robot, a human safety measure, and a mechanism for validating human safety. It is our hope that this book will serve as a guide for conventional robot manufacturers looking to get into the physical helper robot industry.

I. Introduction

Using a physical helper robot might possibly enhance the quality of life for those who use it. These robots are employed in everyday life and assist untrained humans as one of their qualities. In certain cases, they are even closer to the user than the robots employed in factories. Physical helper robots are utilised instead of standard industrial robots and machinery where safety is a concern. As a "personal care robot that physically supports a user to execute essential duties by providing supplementation or augmentation of human skills," the physical assistance robot is defined. ISO 13482 is the worldwide standard that governs such robots. [2] and [3] are two examples of Japanese industrial standards that cover this international standard. Personal care robots have a different design idea than regular industrial robots, which necessitates the development of new safety requirements.

As a result, it is difficult for manufacturers to produce the physical helper robot, despite the fact that such criteria have been set. As a result, we drafted out some guidelines for creating the actual robot assistance. To accomplish this, a danger scenario for the physical helper robot, a human safety measure, and a safety validation test technique were created.

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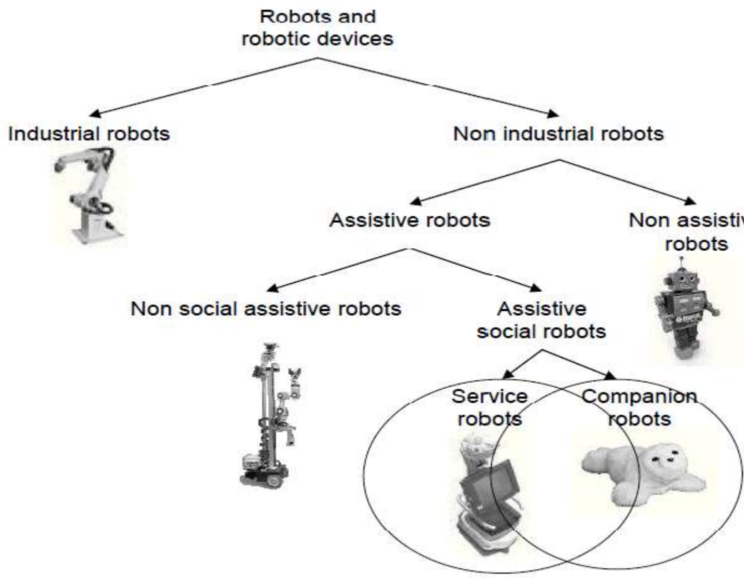

Figure. 1. Physical assistant robot classification

II. Concept Of Safety Guidance

Depending on the sort of support they provide, physical assistant robots may be categorised. Figure 1 depicts the categorization of Japan's Ministry of Economy, Trade, and Industry's physical helper robots. A robot's safety may be greatly impacted by its situational, physical, and functional characteristics. This categorization helps to account for these differences. For each class in this guide, the level of robot safety has been assessed.

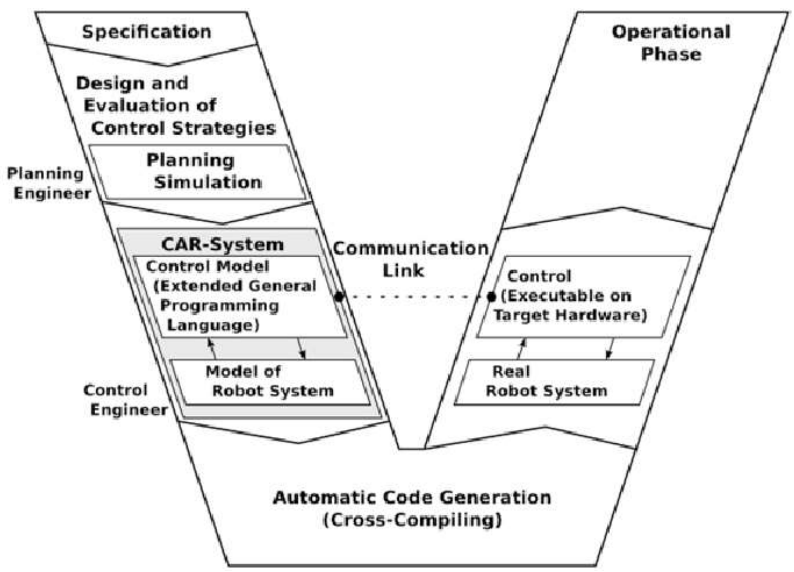

Figure. 2. Design and development of a physical helper robot (V-model)

The "V-model" in Figure 2 summarises the basic principle of this guideline. This is a visual representation of the method through which the physical assistance robot is designed and developed. The process moves in the same direction as the vector, from left to right. The vertical axis represents the conceptual level. The V-model is a way of thinking about system development that is universal. It was widened and tailored to the creation of a physical helper robot in this investigation.

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The usability and target layer is at the top. Contrary to industrial robots, the physical helper robot's operator does not have any formal training in using the device. As a result, it is impossible to create a disciplined work environment, unlike in a factory. In this stage, the robot's impact on the user's quality of life should be evaluated and documented. As a concrete engineering system, this layer includes both robot hardware and software. The robot system should be equipped at this level for both function and safety.

Design is the subject of the first part. The robot's idea is embodied in the robot's hardware and software components. The robot's safety should be evaluated and its architecture updated throughout this step. The risk evaluation is necessary for this step. The idea and example of \sthis method is presented in section III. Validation takes place in the second half. If the safety standard is met, the robot should be tested. In the guideline paper for mechanical, electrical, and electromagnetic safety, many safety test techniques were created and presented. Section IV goes into detail about this procedure.

III. Safety Design

A *Risk assessment*

The robot's safety should be considered in the first part of the V-model. It is necessary to do a risk assessment for this aim. ISO 12100 and ISO 14121 [4] and [5] define risk assessment as a fundamental part of machine safety design. Danger scenario consideration is critical in the risk assessment process. As a result, such standards detail the most common types of hazards, such as vibration and electric shorts. The physical helper robot, on the other hand, may have additional risks that were not previously considered because of the unique circumstances in which it is being used. For example, the danger of skin damage or overpower must be addressed since the robot must approach near to or touch the person.

TABLE I : EXAMPLE OF RISK ASSESSMENT (NON-WEARABLE TRANSFER ASSIST)

Hazardous conditions				Risk estimation		
Phases	Origin	Injury scenario	Potential consequences	Severity	Avoidability	Risk index
Setting	Collision of support bar	The support bar hits the head when inserting sheet under the care taker	Head injury	3	7	21
	Unnatural posture caused by over assist	The care taker is inclined owing to the difference of bar heights	Low back pain	2	7	14
Care	Hand pinch	The hand of the care taker was pinched between descending support arm and bed	Bone fracture	4	8	32
	Over assist caused by error of limiter	The error of limiter makes height of arms unbalanced. The care taker drops from sheet	Head injury	3	8	24

As a result, the risk assessment was conducted for both the usual and virtual physical assistance robots in this guideline document Table I provides an illustration of risk assessment in action. For each robot in the series of instances of risk assessment, a list of typical dangers is provided. Consider the human's capacity to withstand a danger when determining the severity of that threat. As a result, the robustness of the human body is examined and put to the test in a variety of settings. Such a study's findings may be found in the accompanying paper.

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B *Related standards*

It is helpful to look at standards for similar machines while building the physical helper robot's safety features. However, surveying the standards of comparable items isn't something that the average maker can do. Thus, in this advice, the corresponding standards \swere examined. They are classified depending on the category of \shazard and kind of robot as indicated.

For example, the physical assistance robot must take into account risks common to all machines, such as mechanical, electrical, and electromagnetic danger. Physical helper robots, on the other hand, provide a distinct danger that is not covered by any of the relevant standards. As a result, this advice establishes new risk areas.

IV. Safety Validation

V-safety model's measures should be checked in the latter stages. Safety testing methodologies that were created for this purpose are discussed in this safety advice. Such validation techniques and human endurance are discussed in this work.

A *Contact stress*

The repeated friction and distortion of the skin tissue acting on the fixation section of the robot to the user causes the skin damage that is specific to the physical helper robot. This necessitates the development of a safety validation test technique. Use of pig skin, as depicted in Figure 3, is introduced in this safety recommendation. Detailed information on the testing procedure is provided in ISO 13482.

Bone fracture risk must also be taken into account. ISO 15066 [6] is a standard for determining the contact safety threshold, however it does not account for the intensity of the contact in proportion to the degree of contact stress. However, when the physical helper robot is in close proximity to the human, the stress that surpasses the ISO 15066 standard should be taken into consideration. Artificial bone and finite element modelling were used to evaluate the fracture risk of bone under various stress conditions.

B *Posture*

The caregiver's low back discomfort is the primary symptom. Exoskeletons, for example, are physical assistance robots designed to aid the user in lifting the caregiver. A physical helper robot's effectiveness or safety cannot be tested since there is no test technique or threshold.

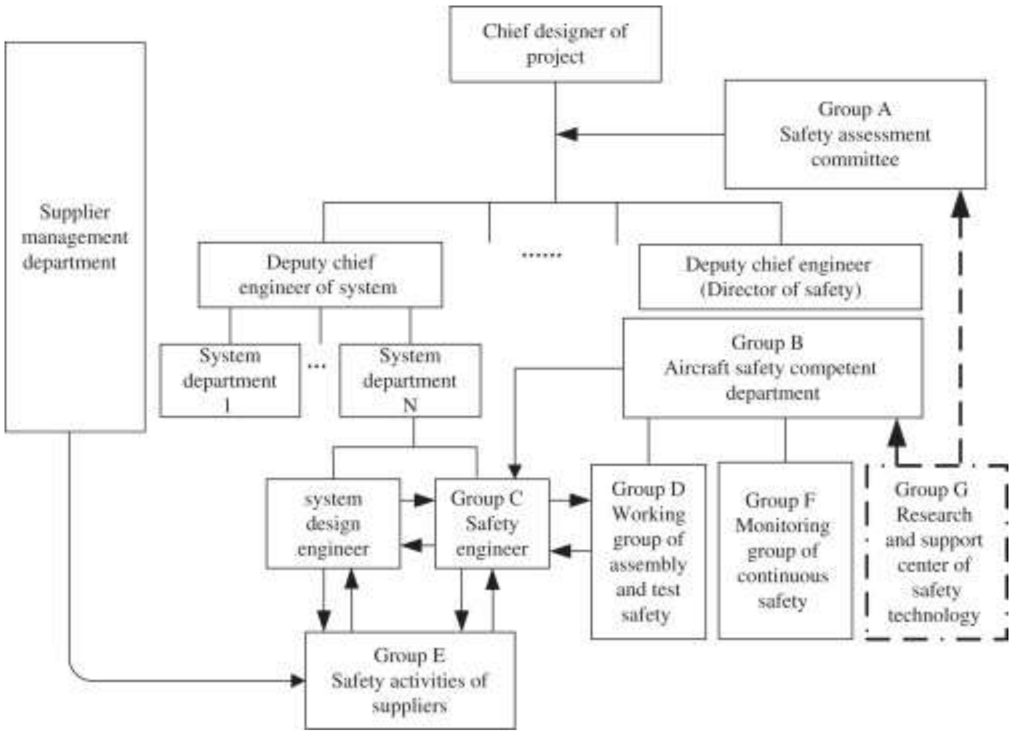

Figure. 3. Process of skin injury safety validation [1]

Due to the mechanism of low back pain, the compression stress acting on the lumbar spine may be used as a measure of pain. Previously documented compression strengths of the lumbar spine were gathered and grouped in this advice. Figure 4 depicts the lumbar spine fracture risk curve.

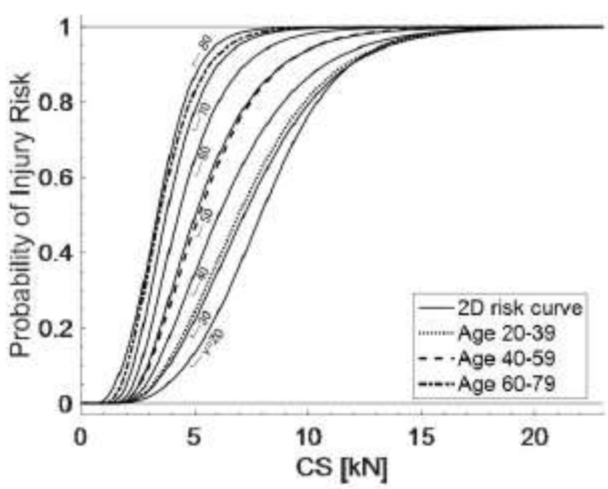

Figure. 4. Lumbar spine compression strength

V. Conclusions

The safety guideline document was published to aid the conventional robot firm in the development of the physical assistance robot. The "V-model," a development path from design idea to user test, was presented to increase the

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safety and usefulness of the robot. In addition to mechanical, electric, and electromagnetic safety, this manual covers the issue of touch safety, which is specific to physical helper robots. We created a physical helper robot danger scenario, a human safety measure, and a safety validation test technique to help with this. As a result of this advice, it was recommended that users' biomechanical limitations be taken into account while creating a robot personal assistant.

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