New Technology

Application Examples of the Wrist Joint Module "i-WRIST™"

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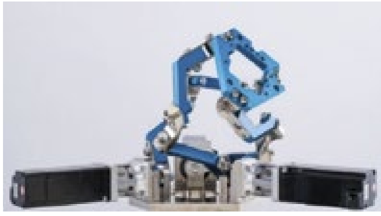

NTN developed an angle control equipment system applying a parallel link mechanism, a constant velocity joint[1)-7)]. We started mass production under the product name of the "i-WRIST™" in August 2018[8)].
We have improved its functions to meet the needs of customers and have launched it on the market with the target of automating and reducing manual work[9)]. The features of the i-WRIST™ like "high-speed angle control" are useful in the appearance inspection process of complex-shaped parts. We would like to introduce application examples that show such advantageous features of the i-WRIST™.

1. Introduction

Due to the reduction in the working population, aging of skilled workers, and rise in personnel expenses, the range of application for robots has spread from work mostly involving tasks that placed a heavy load on operators and extremely dangerous work, such as transporting heavy objects and welding, to more detailed manual labor work. Among these more detailed jobs, appearance inspection still relies heavily on manual labor, and there is an increased demand to automate this type of work. However, conventional robots cannot achieve the speed of visual checks performed by humans, and the automation of appearance inspection for complex shaped parts is particularly lagging.

NTN has proposed the application of Wrist Joint Module "i-WRIST™" to automate tasks handled by humans. i-WRIST™ has received high praise for its strength in "high-speed angle control", and examples of its use in projects to automate visual inspection have increased.

2. i-WRIST™ overview

i-WRIST™ is a robotic module product that achieves smooth movement like a human wrist. **Fig. 1** shows a schematic drawing of the i-WRIST™ unit. The i-WRIST™ unit comprises a parallel link mechanism and drive mechanism. The drive mechanism determines angle orientation in 2degrees of freedom (bending angle and swing angle) at the parallel link mechanism for high-speed and high precision positioning within hemispherical areas. Furthermore, cables can be passed through the internal space of the parallel link mechanism, so the cables do not become twisted even when swing operation is repeated in the same direction.

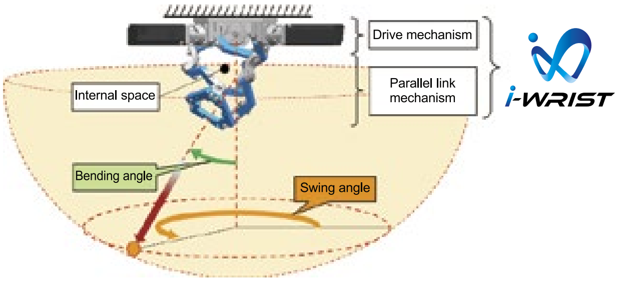

Fig. 1 Schematic drawing of i-WRIST™ unit

3. Features of i-WRIST™ in use at the production site

The use of robots at the production site poses problems for some managers who give comments such as "we installed robots but are not satisfied with the cycle time", "robots are difficult to operate and hard to master" and "we have no space to install robots." To solve these problems, **NTN** proposes a configuration[9)] that combines i-WRIST™ with a linear actuator or rotation actuator. The features of this are shown below.

(1) Fast motion

The moment of inertia at the entire movable section is small, and the robot can move to the target orientation along the shortest route. Therefore, this setup can be particularly effective for work that requires fine movement, something that conventional robots do not do well.

(2) Easy of use

Even operators who do not have expert knowledge of robot language can easily operate this setup using a dedicated console.

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(3) No singularity point

There is no need to create an operation program to avoid the singularity point, as is the case with articulated robots.

(4) Offline teaching

NTN provides a PC-based teaching tool to specify points on a 3D model and configure operating patterns[9].

(5) Space-saving

In combination with a linear actuator or rotation actuator, the machine can be compactly configured, which allows this setup to be installed in a space where a operator worked[9].

Fig. 2 shows examples of application for i-WRIST™. Among such applications, i-WRIST™ is often used in appearance inspection machines equipped with cameras and lighting. An example of this is shown below.

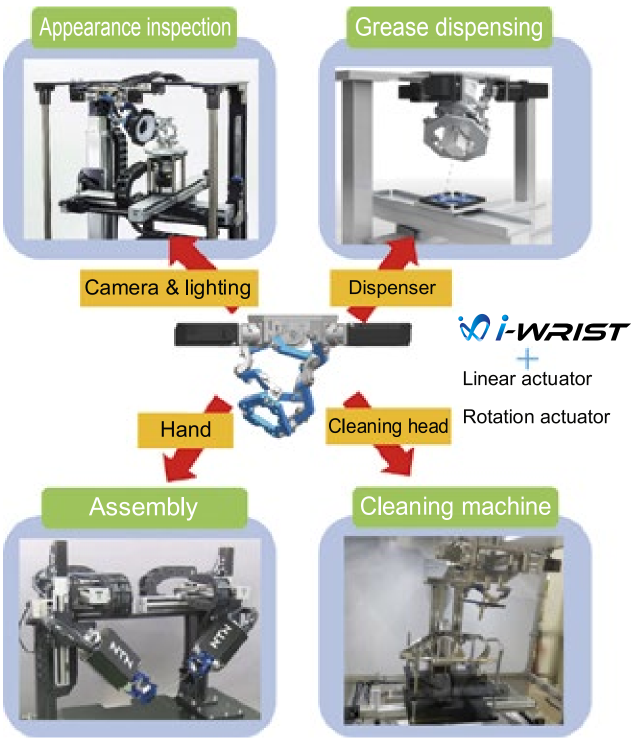


Fig. 2 Example of applications for i-WRIST™

4. Example of applications for i-WRIST™ in appearance inspection

During appearance inspection of workpieces that have a 3D shape or complex shape, such as casting parts and resin molded parts, humans can quickly and skillfully visual inspection multiple locations of the workpiece from various angles while changing how lighting is shone onto the workpiece and the angle of the workpiece. This type of high-speed inspection is exceedingly difficult to automate. However, many examples exist in which this difficulty has been resolved using the features of i-WRIST™. For example, as shown in **Fig. 3**, inspection processes that have so far required the use of two robots can now be configured using a single i-WRIST™ unit, and this has been evaluated as achieving the required cycle time and has been adopted for use. Below introduces more specific examples of the application in appearance inspection.

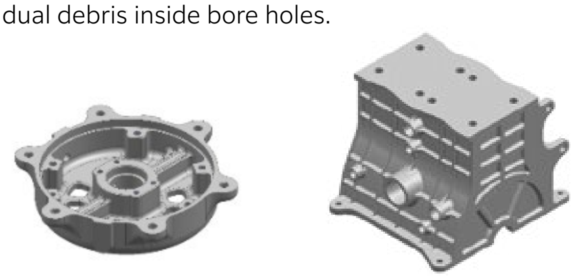
(a) With conventional robots (b) With i-WRIST™

Fig. 3 Example of application at the production site

4.1 Example of application for casting parts

During appearance inspection of small casting parts, such as for an automotive compressor as shown in **Fig. 4 (a)**, appearance inspection of 0.2 seconds per single point -- about 2.5 times the speed of conventional robots -- was achieved. **Fig. 5** shows an example of the configuration for this system. This configuration involves mounting a camera onto i-WRIST™ and controlling the angle, while a rotation actuator and linear actuators are used to position the workpiece. The rotation actuator rotates the workpiece while images are captured from multiple directions. This enables high-speed inspection for defects such as surface scratches, dents, and residual debris inside bore holes. This configuration can also make the machine more compact.

During appearance inspection of large casting parts such as for an engine block or transmission case as shown in **Fig. 4 (b)**, appearance inspection of 0.3 seconds per single point was achieved. **Fig. 6** shows an example of the configuration for this system. This configuration involves mounting a camera onto i-WRIST™ installed at an incline and using a rotation actuator and linear actuators to position the workpiece. Installing i-WRIST™ at an incline enables images to be taken of the workpiece while looking up at the workpiece from below. This enables high-speed inspection for defects such as scratches on uneven surfaces at the side of the workpiece, dents, and residual debris inside bore holes.



(a) Small casting part (b) Large casting part

Fig. 4 Casting parts

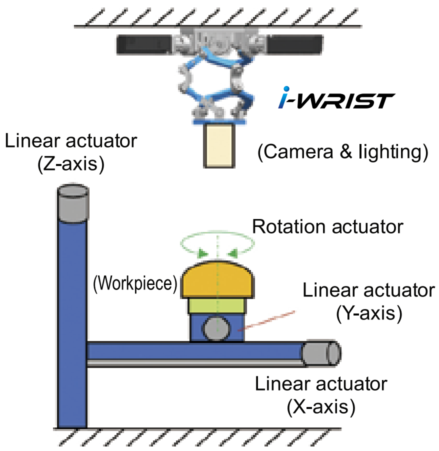


Fig. 5 System configuration example (1)

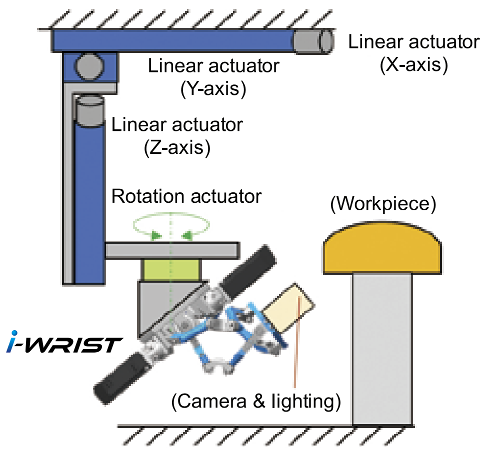


Fig. 6 System configuration example (2)

4.2 Example of application for automotive resin molded parts

During appearance inspection of automotive resin molded parts integrated with various sensors as shown in **Fig. 7**, visual inspection of 0.3 seconds per single point was achieved. **Fig. 8** shows an example of the configuration for this system. This configuration involves fixing the camera and lighting while a chuck mounted onto i-WRIST™ holds the workpiece. The workpiece is positioned using i-WRIST™, a linear actuator and a rotation actuator. The use of a rotation actuator achieves a compact system configuration that can minutely change the positioning of the workpiece while rotating it for a single revolution at the same position. This configuration enables the system to inspect the appearance of surface (for scratches, bubbles and burrs) and check whether any connector pins and sensor parts are missing.

Fig. 7 Resin molded part

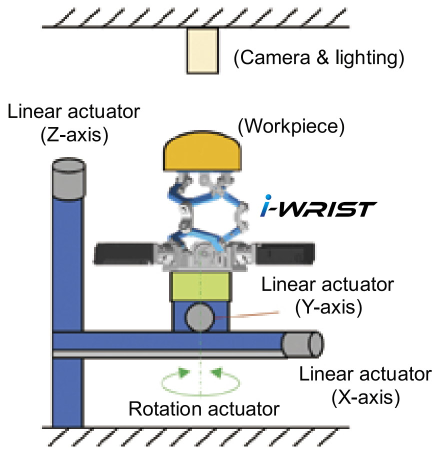


Fig. 8 System configuration example (3)

4.3 Example of application for automotive electronic control unit

With the electronification of automobiles, examples of appearance inspection have increased for automotive electronic control units, such as gear boxes integrated with electronic circuit boards as shown in **Fig. 9**. This type of unit has sections where images are difficult to capture, such as the back of circuit boards, so a person visually inspects blind spots that are difficult to see while changing the angle. The system configuration shown in **Fig. 6** enables images to be captured of electronic control units, including the back of circuit boards from multiple directions. The illumination angle can be finely adjusted onto the circuit board using i-WRIST™ so that light shines onto blind spots. This enables inspection of blind spots at the back of the circuit board (the soldered surface) as shown in **Fig. 10**. In this example an inspection speed of 0.3 seconds per single point was achieved to check for missing parts on electronic circuit boards, and for appearance defects on the resin surface such as scratches, dents, and burrs.

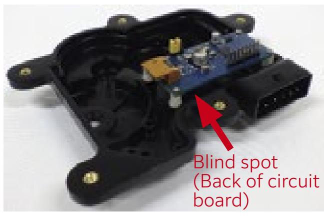


Fig. 9 Electronic control unit

Fig. 10 Example of captured image (back of circuit board)

4.4 Through-hole and screw-hole internal inspection

There is also a high demand for automating inspection of burrs and residual debris inside through-holes and screw-holes. Using the pivot movement of the i-WRIST™ enables the angle to be changed while maintaining working distance from the camera to the reference point by linked i-WRIST™ and linear actuators. Using this action enables images to be captured as shown in **Fig. 11**. This can make it easy to inspect the entire inside diameter surface of a hole.

Fig. 11 Pivot movement

5. Efforts to increase the range of application for i-WRIST™

Amid the launch of i-WRIST™ to the market, we received praise for i-WRIST™ high speed operation, and its excellent ability to work without singularity points, which is a challenge for conventional robots. At the same time, we received many requests for i-WRIST™ to handle similar payloads as conventional robots and have investigated methods to achieve this.

Until now, maximum load capacity was restricted to 1 kg so that i-WRIST™ could be used at high speed. However, we developed a new grade that increases the maximum payload to 3 kg by establishing a mode that optimizes the control method to match the load capacity. As a result, it is now possible to mount large-scale lighting and multiple lighting onto i-WRIST™ for appearance inspection. Using large-scale lighting enables images to be captured over a large area in a single shot, and this reduces the number of inspection points, which leads to a shorter cycle time. Furthermore, using multiple lighting increases the variation of how lighting can be shone onto a work piece being inspected. This provides support for work pieces that are difficult to inspect.

In addition to appearance inspection applications, i-WRIST™ can be applied to such as the deburring process in which the machining load acts on the end effector, and the welding process in which the end effector weight is large.

6. Summary

This paper introduced examples of appearance inspection using high-speed angle control, which is a strength of i-WRIST™. Using i-WRIST™ can replace sight checks that are difficult to automate and achieve a cycle time that cannot otherwise be achieved with conventional robots.

In the future, there will be greater demand for automating complex work performed by humans, such as deburring and assembly to accompany the decrease in the working population. i-WRIST™ introduced here is a robotic module product that can achieve automation of manual work at a work speed and smooth movement like human hands. **NTN** will continue to improve performance and create examples of applications to contribute to automating and optimizing the production site and stabilize quality.

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Photo of author

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