Development of Automatic Deboning Robot for Pork Thigh





K. Toyoshima*[1] (1965) T. Umino*[2] (1971) K. Matsumoto*[2] (1976) O. Goto*[2] (1978) K. Kimura*[2] (1972)

1. Abstract

Pork thigh is a “Non-uniform Soft Object”; its characteristic is soft and not uniform in shape due to individual difference. A progress of automation for deboning from a pork thigh has been delayed because of difficulty due to such characteristics. The manual work for such a “Non-uniform Soft Object” is so complicated and difficult for an untrained person or robots because it requires skills of craftsmanship, ability of analyzing situation in processing and physical flexibility.

We developed a cutting tool with mechanism that realizes the flexibility of the human wrist, in order to cut accurately along the bones which have a complicated three-dimensional shape and changing their forms (bending or twisting of joint) and positions at every moment during the process. By attaching such a cutter tool to a robot flange, it is able to adjust the position of the knife reflexively. Robot system with the cutter tool has realized the automatic deboning at high-speed and high quality same as a human work.

2. Technical Features

Automatic deboning robot system for pork thigh (Figure 1) performs processing to remove (deboning) the femur and shank bone from a pork thigh automatically. Processing capacity is 500 pork thighs/ hour.

Figure 1 Automatic deboning robot system for pork thigh

The process flow is described below. A loading robot arm picks up a pork thigh from the supplying conveyor, and then puts into the continuous transport system. After loading, X-ray image processing recognizes internal bone shapes and distinguishes a left leg or a right leg. Robot controller generates a cutting trajectory that matches each pork thigh based on the information of X-ray image processing. Robot arms using a knife perform "Slitting" that cuts along the bone shape. The pork thigh meat is stripped step by step from the bone using separating plates, and is cut off at a sinew on the anatomical critical point, and finally it is separated completely into meat and bones.

In order to perform an accurate "Slitting", a trajectory is generated based on X-ray images, and 6-axis robot arms are used for the "Slitting" motion. However, it is impossible to perform "Slitting" accurately for a “Non-uniform Soft Object” even if the knife passes through the planned trajectory, because of the material characteristics. Furthermore, there are also some risks that the knife gets stuck into the bone if an angle of the blade is too hard toward bone surface.

We provided two-degree freedom between a knife and a flange of the 6-axis robot in order to realize an accurate and high-speed cut while avoiding risks. One degree of freedom is a liner motion of the knife perpendicular to the lateral surface of the knife. It has a structure as a centering device by pressing the knife from both sides with springs. It has an effect to adjust the knife position against differences in the direction of the thickness of the bone from the planned trajectory. In addition, it also gives an adjusting function for the cutting force by setting a distance where a knife presses against a spring. Another degree of freedom is intended to make swing for the angle of the knife to avoid the knife stuck into the bone. The center of the swing was positioned on the shifted place from the knife blade to the traveling direction of the knife. The angle of the knife is able to direct toward the center of swing at all times because the center of swing always proceeds on ahead of a knife blade. Therefore, it is possible to swing the angle of the knife before the knife gets stuck into the bone. (Figure 2 and 3)

It enables the trajectory correction by the reflection motion, and realizes high-speed processing for a “Non-uniform Soft Object” by using a mechanical compliance function similar to the flexibility of the human wrist.

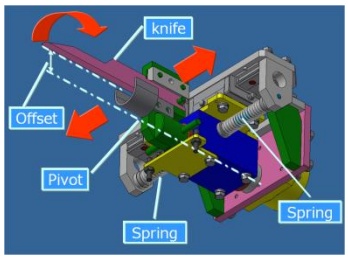

Figure 2 Cutter tool

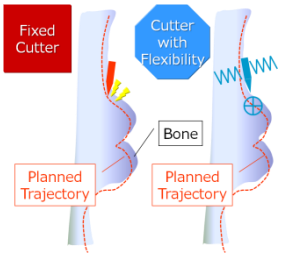

Figure 3 Trajectory correction action

3. Summary

The developed robot system has been installed in Europe as the trade name "HAMDAS-R". This system has contributed to solve the several issues such as releasing workers from a hard work, difficulty of ensuring labor and decreasing retention rate of labor.

There are no similar machines to "HAMDAS-R" in the world. "HAMDAS-R" shows new possibilities of automation for craftsmanship especially processing for a “Non-uniform Soft Object” such as processes of food processing among others.

*[1] Member, Mayekawa MFG. Co., LTD. (774, Nagatoro Saku, Nagano, 385-0021, Japan)
*[2] Mayekawa MFG. Co., LTD. (774, Nagatoro Saku, Nagano, 385-0021, Japan)