Stable gait generation of bipedal robots based on asymmetry of impact posture considering the sliding characteristics of ground contact point

1910117 JUNG DONGGYUN

Stable gait generation is an indispensable ability for walking robots. However, it is very difficult to generate stable gait on a rough terrain, and many studies are actively underway. A low friction road surface is the representative rough terrain, so research about stable gait generation on a low friction road surface is being conducted most actively. In a previous study on the adaptability of a walking robots on a low friction road surfaces, it was revealed that the smaller the horizontal ground reaction force and the larger the vertical ground reaction force immediately after a collision, the walking robot can walk on a road surface with a smaller coefficient of friction. I also think adaptability to high friction road surfaces is important as well as low friction road surfaces. Painlevé paradox phenomenon occurs on a high friction road surface, which causes the vertical ground reaction force of the support leg immediately after the collision to be less than zero, making it impossible to generate a gait. According to a prior study, this phenomenon is more likely to occur as the angle between the swing leg and the road surface just before the collision is smaller and the coefficient of friction increases.

In order to realize stable gait generation even on low friction road surfaces and high friction road surfaces, I propose telescopic-legged biped model with asymmetric impact posture. Using this model, we can bring the center of mass closer to the point of impact. So that, the vertical ground reaction force immediately after the collision becomes larger, and the horizontal ground reaction force becomes smaller, so the adaptability on the low friction road surface will be high. In addition, as the angle between the swing leg and the road surface just before the collision will be close to 90 degrees, it is expected that even on a high friction road surface, the robot will be able to walk without causing the Painlevé Paradox phenomenon.

In Chapter 2, I investigate the stable gait generation on low friction road surfaces by making impact posture asymmetric using telescopic-leg. I decided to generate gait by adjusting the length of the two legs and the angle of the hip according to the impact posture. First, I will find the conditions of converging gait according to the collision posture. After that, I analyze the gait and examine the walking performance according to the collision posture.

The model in Chapter 2 has a problem of falling forward due to its high acceleration on a high friction road surface. In Chapter 3, therefore, I am going to realize stable gait generation on high friction road surfaces by adding upper body to slow down. Then, I investigate the condition of stable gait

generation according to the upper body's control parameters. After that, I analyze the gait.

In Chapter 4, I examine the possibility of stable gait generation on road surface with inconsistent coefficient of friction for telescopic-legged biped model with upper body used in Chapter 3. In the road surface with inconsistent coefficient of friction, the gait does not converge because the coefficient of friction is changed randomly. In this chapter, therefore, I observe the tendency of conditions in which stable gait generation becomes possible. After that, I analyzes the gait choosing one stable gait generation condition.

In this research, it is clarified the following.

- It is possible to generate stable gait on low friction road surfaces by asymmetricizing the impact posture using telescopic leg
- On the low friction road surface, there is a section in which gait performance changes rapidly depending on the impact posture.
- On the low friction road surface, the greater the angle between the swing leg and the road surface just before the collision, the more conditions of hip angle that can generate stable gait are.
- On the low friction road surface, if the angle between the swing leg and the road surface increases just before the collision, the hip angle must also increase to generate stable gait.
- In a model with only legs, it is impossible to generate stable gait on high friction road surface due to large acceleration.
- With properly designing the control system by adding the upper body, deceleration becomes possible, and the stable gait generation on high friction road surface becomes possible.
- If the upper body is added and controlled, the vertical ground reaction force of support leg may be less than zero, making it impossible to generate gait.
- The telescopic-legged model, which is slowed down by adding the upper body, can generate gait on road surfaces with inconsistent coefficient of friction. However, the coefficient of friction changes randomly, so the gait does not converge, but the robot can walk for a long time.

In this research, it is possible to generate stable gait on a road surface with inconsistent coefficient of friction by adding the upper body. However, a better control method is needed because there are some cases that the

vertical ground reaction force of the support leg becomes less than zero and the robot falls. In addition, a more detailed analysis is needed because no mathematical and dynamic analysis of this model has been done yet. In this research, I assume a hard and flat road surface in this research. In reality, however, there are many soft and bumpy road surfaces, so it is a future work to make it possible to generate stable gait on various road surfaces. I think that we can make it possible to generate stable gait on road surface with varying height or inclined by using the model in this research.