CHAPTER 5 - CONCLUSION AND FUTURE RECOMMENDATION

5.1. Conclusion

Through the research methodology accounted on Chapter 3 and the results obtained and discussed on Chapter 4, it may be concluded that the research problems defined in Section 1.2 have been solved:

1. The parameters defining the sinusoidal gait model for the newly-developed Cheetah-cub Quadruped Robot have been determined.

   The sinusoidal gait is modeled as rhythmic sinusoidal wave similar to the stride cycle of cats, consisting of hip and knee sinusoidal joint angle profiles and phase differences among the legs. A complete parameters set includes swing and stance period, minimum and maximum joint angle value, oscillation amplitude during swing phase, oscillation amplitude during stance phase, and phase differences of the legs.
2. The capability of sinusoidal gait in generating periodic, rhythmic leg motion has been investigated.

   The states of the legs during motion are simulated by the *GaitSimulator* program and can be visually observed to determine whether the movement sequence of the legs is satisfying.
3. Necessary adjustment on the sinusoidal gait has been made so that the gait can be implemented on the actual robot.

   The actual quadrupedal robot is designed and built based on the design of the Cheetah-cub quadruped robot, especially on the design of leg, cam and pulley system and diagonal spring attachment. The selected actuator type is smart servo motor, which has the ability of performing either position control or continuous rotation speed control. The mechanical model of the newly-developed quadruped robot consisting of the kinematic and dynamic model was developed and used as the basis of determining the required mechanical torque to be supplied by the servo motors used.

   Gait implementation was done by means of approximation through array of setpoints generated by the *GaitSetpoint* program. Approximation of the gait may use either position control approach or speed control approach. The test on three parameters set which were mentioned in Chapter 4 has concluded that the use of position control approach is more applicable than the speed control approach, in which the maximum servo rotation speed requirement is more demanding. Therefore, only the position control mode was actually implemented on the actual quadruped robot.

When the sinusoidal gait was implemented on the newly-developed quadruped robot for the first time, the body of the robot tended to tilt to the left due to the difference of force magnitude exerted by the linear spring for countering the load on each leg. However, when the lower part of the robot was slightly supported while it was moving, the robot was able to move forward, although the tip of the leg frequently grazed the rubbery surface. However, after replacing the springs (so that the spring length is equal for each leg instead of longer at the back or at the front), the robot was able to move forward without any additional support.

Another problem lied on the pulley system. The string used for retracting the leg regularly left the idler when the leg was compressed by the weight of the platform and became loose, while ideally the tension of the string was meant to be kept at most of the time.

5.2. Future Recommendations

The following ideas are recommended to be implemented in future development:

1. Perform Gait Parameters Sensitivity Study to fully understand the individual effect of each gait parameters, and may assist gait parameters selection process.
2. Improve the pulley system by modifying the idler so that the string will not be able to left the idler.
3. Modify the cam joint angle or increase the cam radius to compensate for the loose part of the string due to the load exerted on the leg.
4. Implement proximity sensor on the robot leg to provide feedback for modifying the cam joint angle.