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Hexa-Quad Transformation Control for Hexapod Robot Based on Support Polygon Pattern

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Abstract: This paper presents a leg reconfigurable technique to optimize the multi-legged robot operation and walking performances. A hexapod-to-quadruped (Hexa-Quad) transformation technique is proposed to optimize hexapod legs on certain situation that need some legs to be disabled as a leg to do other tasks/operations. By separating two legs from the others, hexapod robot is able to be configured as quadruped robot configuration. Quadruped robot configuration is stand within dynamically and statically stable criteria if compare to the hexapod robot that has only statically stable criteria. Thus, it is very crucial to have a stable transformation technique during walking and operation session. Therefore Hexa-Quad is proposed with reference to the defined support polygon that based on its body area. A real-time based model of hexapod robot (4-DOF/leg) control architecture with Hexa-Quad transformation is designed and verified using separated 3D simulators.

Keywords: Hexa-Quad Transformation, center of mass, support polygon

1 INTRODUCTION

Multi-legged robot or so called active suspension vehicle (ASV) has significant advantages if compare to the wheel type robot especially on facing irregular and mountainous terrain. The advantages of multi-legged or legged robot can be seen obviously on inspired life living form; legged creatures. Raibert in his book has mentioned that only about half of the earth 's landmass is accessible to existing wheeled and tracked vehicles ,whereas a much larger fraction can be reached by animals on foot[1].

In multi-legged robot research and development, several studies have been done to achieve good adaptability, function, high flexibility and extensibility with extreme and unknown terrain. The progress emphasized in all expects and hierarchy of multi-legged system such as system mechanism, structure design/configuration, software development/control technique and electronics unit design. In control technique level, reconfiguration technique is one of the important parts in legged robot control, which is emphasized on recovery action [2] and multi-tasking. Therefore stability become a main point in this research that involving center of mass (CoM) of the legged robot and its support polygon. The larger the *support polygon* developed by the robots the bigger the probability for the robot to remain upright without overturning when it stops walking at any moment during the walking period, and this is called statically stable walking or static stability. Static stability occurs when CoM lies completely within the support polygon and the polygon's area is greater than zero, and hence static stability requires at least three points of ground contact [3]. Robot's CoM represented a significant aid in maintaining the stability[4] and as additional source of information in identified process and stability indicator. Moreover, CoM is calculated to provide critical to access rehabilitation success in pathology detection and in describing gaits[5]. In reconfiguration aspect, the CoM's of legged robot is will be reallocated since the changing of in the structure or leg configuration of the robot.

Therefore in this study, control technique on hexapod configuration to quadruped configuration for a hexapod robot (Hexa-Quad) is proposed. Hexapod is one of the statically stable configurations of multi-legged robot that has potential to be reconfigured into less than six legs such as quadruped and bipedal configuration. Transforming hexapod to bipedal configuration is considered as critical configuration for hexapod unless there have a special design on leg configuration and robot body's shape itself (other than common hexapod's body shapes; square, trapezium, round or hexagon body). The quadruped configuration is selected since this configuration is in between statically and dynamically stable and suitable for any common shape of hexapod robot's body. Static stability assumes the vertical projection of the CoM always remain