A Topological Approach to Gait Generation for Biped Robots: Software Debugging Tips

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I. Debugging Error Messages from the algorithm in Section III.D

When a call to the algorithm outlined in Section III.D results in an error state, the following are a list of potential sources of errors and solutions.

A. If the plot of $I(\tau)$ is the constant zero line $I(\tau) = 0$

In this case, the output indicates that equilibrium branches in the state-time subspace are not one dimensional. In other words, there exists a configuration parameter, similar to the switching time, that can be varied while still keeping the robot at an equilibrium configuration. For example, Atlas' wrist joints about the x axis can be continuously rotated creating a three-dimensional branch of equilibrium gaits parameterized by the switching time and the two joint parameters. For this case, we recommend

1) checking the model as the free parameter might be due to a joint, as in Atlas' case. A few potential solutions are to remove the corresponding periodicity constraint, specify a trajectory for the joint to follow using a VHC, or keep the joint locked using a VHC, and
2) removing redundant periodicity constraints; a periodicity constraint is redundant if there exists another periodicity constraint or VHC that already makes the joint track a periodic trajectory. This can often also lead to the elimination of a state or control parameter.

B. If the plot has no zero crossings $I(\tau) \neq 0$

This situation can occur for several reasons, including

1) the search window is too small, in which case, increase it,
2) the biped may have sufficient control authority (see remark in Section IV.B). We recommend proceeding in a manner similar to the example with MARLO, which uses the algorithm in Section IV.B, or
3) singular points may not exist on the equilibrium branch being searched; based on experience, we typically assume a search window of $\tau \in [0, 1]$ (in seconds) is sufficient to assume that there are no singular points on the branch.

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