The Jansen Linkage

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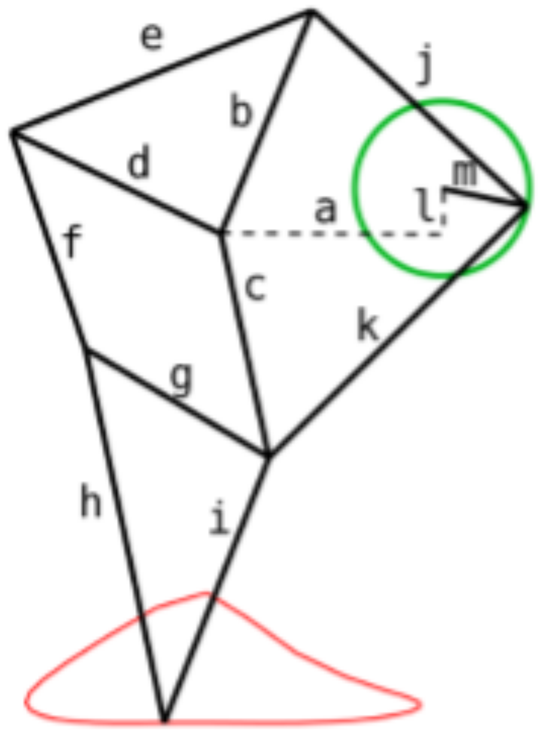
Abstract

The Jansen linkage is an eleven-bar mechanism designed by Dutch artist Theo Jansen in his collection “Strandbeest.” The mechanism is crank driven and mimics the motion of a leg. Its scalable design, energy efficiency, and deterministic foot trajectory show promise of applicability in legged robotics. Theo Jansen himself has demonstrated the usefulness of the mechanism through his "standbeest” sculptures that utilize duplicates of the linkage whose cranks are turned by wind sails to produce a walking motion. The motion yielded is smooth flowing and relatively agile. Because the linkage has been recently invented within the last few decades, walking movement is currently the primary application. Further investigation and optimization could bring about more useful applications that require a similar output path when simplicity in design is necessary.

Objective

The objective of this poster is to show the kinematics of the Jansen linkage and and possible further applications and optimizations to an already remarkable linkage design.

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The Kinematics

The Jansen linkage is a one degree of freedom, planar, 11 mobile link leg mechanism that turns the rotational movement of a crank into a stepping motion. The brilliance behind this design is that it mimics the path of a human's foot when stepping in a forward direction. It also does this with minimal torque input by the crankshaft. As you read in the abstract, Theo Jansen’s design is so energy efficient that he decided to power it with wind energy. This phenomenal efficiency could be the cornerstone to the motion of human-like robots in the future. The mechanical design can produce infinite paths because the shape and design of the path is directly proportional to the ration of the link lengths to one another.
The column of link ratios above will give you the human like stepping motion that is desired. Once built, a position analysis can be performed on this mechanism to find the position of each joint on this linkage. Once the positions of the joints and their link lengths are known, it is possible to show the full motion of the mechanism. While the crank rotates 360° clockwise, the combination of lengths, angles, and physical connections work in unison to drive the linkage through its predetermined path.

Applications and Advancements

Currently, the primary application of the Jansen linkage is walking motion used in legged robotics. In order to create a robot that can move independently, a minimum of three linkage attached to a motor are required. An agile and fluid motion is created by the linkage.With the linkage’s mobility, robots are capable of moving both forwards and backwards and pivoting left to right without compromising equal traction. The unique gait pattern of the mechanism allows digitigrade movement, step climbing, and obstacle evasion. However, the gait pattern is maladaptive which limits its jam avoidance.

The Jansen linkage is an important building component in Theo Jansen’s collection “Strandbeest.” He has designed his creations to store wind energy and has even created them to be able to detect and avoid water. Jansen refers to his inventions as “animals” and as new forms of life. Jansen hopes to advance his entire collection to survive by themselves on the beach.

Conclusion

In conclusion, the Jansen linkage demonstrates an exceptional use of a combination of four-bar linkages using one motor to move the entire leg. It is a simple, and inexpensive structure that creates a complex path using circular motion. Despite being a recent invention, the Jansen linkage has already proven its energy efficiency and usefulness. With further advancements, the possibilities for the Jansen linkage are limitless.

Sources:
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