CLAIMS

1. A swing apparatus (10), comprising:

a magnetic drive (20), comprising:

an electromagnet (51); and

a plurality of permanent magnets (52, 53); and

a controller (2102), coupled to the electromagnet (51) to activate the electromagnet (51) by applying an activation current having a polarity selectable from a first polarity and a second polarity and thereby initiating a motion of at least a portion of the swing apparatus (10), the controller (2102) being configured to:

A1) apply the activation current having one of the first polarity and the second polarity;

A2) determine if at least the portion of the swing apparatus (10) has moved at least a predetermined amount;

A3) if, after a predetermined time period, at least the portion of the swing apparatus (10) has not moved by at least the predetermined amount, then switch the polarity of the activation current to the other of the first polarity and the second polarity; and

A4) repeat A2) and A3) until it is determined, at A2), that the swing apparatus (10) has moved by at least the predetermined amount.

2. The swing apparatus of claim 1, further comprising:

a plurality of optical sensors coupled to the controller, the plurality of optical sensors comprising:

a first light source to emit a first light beam propagating along a first optical path;

a first detector, spaced from the first light source and disposed in the first optical path to detect the first light beam;

a second light source to emit a second light beam along a second optical path substantially parallel to the first optical path and offset from the first optical path by a separation distance;

a second detector, spaced from the second light source and disposed in the second optical path to detect the second light beam; and

an optical encoder strip disposed in the first optical path and the second optical path to modulate detection of the first light beam by the first detector to affect a change in state of the first detector, and to modulate detection of the second light beam by the second detector to affect a change in state of the second detector,

wherein the controller is further configured to determine, at A2), if at least the portion of the swing apparatus has moved at least a predetermined amount by detecting a change of state of at least one of the first detector and the second detector.

3. The swing apparatus of claim 1, wherein the controller is further configured to, when it is determined at A2) that the swing apparatus has moved by at least the predetermined amount:

A5) determine if the portion of the swing apparatus has changed direction of swing motion.

4. The swing apparatus of claim 3, wherein the controller is further configured to, when it is determined at A5) that the portion of the swing apparatus has not changed direction of swing motion, repeat A2) and A3).

5. The swing apparatus of claim 3, wherein the controller is further configured to, when it is determined at A2) that the swing apparatus has moved by at least the predetermined amount:

A6) increment a swing angle measure associated with the motion of the portion of the swing apparatus.

6. The swing apparatus of claim 5, wherein the controller is further configured to, when it is determined at A5) that the portion of the swing apparatus has changed direction of motion:

A7) switch the polarity of the activation current being applied to the electromagnet.

7. The swing apparatus of claim 6, wherein the controller if further configured to, after A7):

A8) if the swing angle measure exceeds a predetermined setpoint, set the activation current to zero.

8. The swing apparatus of claim 7, wherein the controller is further configured to, after the activation current is set to zero at A8), repeat A2) and A3).

9. The swing apparatus of claim 7, wherein the controller is further configured to, after A7):

A9) if the swing angle measure is less than the predetermined setpoint, modulate the activation current.

10. The swing apparatus of claim 9, wherein the controller is further configured to modulate the activation current at A9) by:

computing an error value based on the swing angle measure and the predetermined setpoint;

computing one or more of a proportional term, a derivative term, or an integral term based on the error value; and

modulating the activation current based on the one or more of the proportional term, the derivative term, or the integral term.

11. The swing apparatus of claim 9, wherein the controller is further configured to, after the activation current is modulated in A9), repeat A2) and A3).

12. The swing apparatus of claim 1, wherein the controller is further configured to determine when the portion of the swing apparatus changes direction during the motion without determining when the portion of the swing apparatus passes through an equilibrium position of the motion.

13. The swing apparatus of claim 1, wherein the predetermined time period is based on a desired frequency of the motion of the swing apparatus.

14. The swing apparatus of claim 1, an initial instance of the application of the activation current has the first polarity and in A2) it is determined if at least the portion of the swing apparatus has moved at least the predetermined amount from an initial position of at least the portion of the swing apparatus upon application of the initial instance of the activation current

and further comprising, in A3), starting a timer upon the application of the initial instance of the activation current and wherein the predetermined time is measured from the start of the timer.

15. The swing apparatus of claim 1, wherein the predetermined time period is based on a desired frequency of the motion of the swing apparatus.