We claim:

1. A method for estimating a position of a heart pump system in a patient, the method comprising:

receiving first data indicative of a time-varying motor current during a first period of time in the heart pump system, wherein the time-varying motor current corresponds to an amount of current delivered to a motor of the heart pump system, while the heart pump system is operating in the patient;

receiving second data indicative of a time-varying differential pressure during the first period of time, wherein the time-varying differential pressure corresponds to a difference in pressure between an inner portion of the heart pump system and an outside of the heart pump system and is further indicative of a position of the heart pump system relative to patient's heart;

receiving third data indicative of time-varying motor current during a second period of time later than the first period of time; and

determining an estimate of time-varying differential pressure during the second period of time from the third data and a relationship between the first data and the second data, wherein the estimate is usable to predict the position of the heart pump system in the patient.

2. The method of claim 1, wherein the second data is received from a differential pressure sensor on the heart pump system, and the determining the estimate of time-varying differential pressure during the second period of time is in response to determining that the differential pressure sensor has failed.

3. The method of claim 1, wherein the determining that the differential pressure sensor has failed occurs when no data is received from the differential pressure sensor during the second period of time.

4. The method of any of claims 1-3, further comprising:

providing a first indicator that the differential pressure sensor has failed; and

providing a second indicator that the estimate of time-varying differential pressure during the second period of time is simulated.

5. The method of any of the above claims, wherein the determining the estimate of time-varying differential pressure during the second period of time comprises determining a time series of estimated points by determining whether the third data corresponds to a first phase or a second phase in the relationship between the first data and the second data.

6. The method of claim 5, wherein identifying whether the additional data corresponds to the first phase or the second phase comprises:

determining a diastolic period within the additional data, wherein the diastolic period starts at a starting point and ends at an ending point in time;

determining a slope of the additional data between the starting point and the ending point;

in response to determining the slope is positive, determining the additional data corresponds to the first phase; and

in response to determining the slope is negative, determining the additional data corresponds to the second phase.

7. The method of any of the above claims, further comprising:

determining, based on the estimate of time-varying differential pressure, at least one of: flow rate, position, and suction associated with the heart pump system

8. The method of any of the above claims, further comprising displaying at least one of: the time-varying differential pressure, the motor current, and the estimate of time-varying differential pressure.

9. The method of any of the above claims, further comprising determining the time-varying differential pressure is drifting.

10. The method of claim any of the above claims, wherein determining the time-varying differential pressure is drifting comprises:

comparing the time-varying differential pressure to the estimate of time-varying differential pressure for a second period of time;

calculating, based on comparing the time-varying differential pressure to the estimate of time-varying differential pressure, a difference between the time-varying differential pressure and the estimate of time-varying differential pressure over the second period of time;

comparing the difference to a differential pressure signal threshold; and

determining, based on comparing the difference to the differential pressure signal threshold, the difference is greater than the differential pressure signal threshold.

11. The method of claim any of the above claims, further comprising:

based on determining the time-varying differential pressure is drifting, displaying a notice indicating the differential pressure sensor needs to be re-calibrated.

12. The method of claim any of the above claims, further comprising:

based on determining the time-varying differential pressure is drifting, automatically re-calibrating the differential pressure sensor.

13. The method of any of the above claims, wherein the relationship between the relationship between the first data and the second data is determined by:

determining a correlation, for each point of time in the first period of time, between the motor current and the time-varying differential pressure; and

calculating a multilinear fit for correlation, wherein the multilinear fit is indicative of operating characteristics of the heart pump system.

14. The method of any of the above claims, wherein the first data and second data are representative of the heart pump system operating at a first operating level, and wherein the method further comprises:

changing operation of the heart pump system to a second operating level; and

scaling, based on changing the operation of the heart pump system to the second level, the relationship between the first and second data to account for the second operating level,

wherein determining the estimate of time-varying differential pressure is further based on scaling the relationship.

15. A system comprising a controller configured to perform the method of any of claims 1-14.

16. A heart pump system comprising:

a pump comprising a pump housing and a rotor, the pump housing having a proximal end;

a cannula comprising a proximal end that interfaces with the distal end of the pump housing and a distal end, the pump being configured to be operated by a motor;

an elongate catheter extending proximal of the pump housing;

one or more sensors, including a differential pressure sensor; and

a controller configured to:

perform the method of any of claims 1-14.

17. The heart pump system of claim 16, wherein the pump is configured to be placed such that cannula extends across an aortic valve of the patient, the distal end being located within a left ventricle of the patient, and the proximal end being located within an aorta of the patient.

18. The heart pump system of claim 16, further comprising a flexible projection extending distally away from the distal end of the cannula.

19. The heart pump system of claim 16, wherein the elongate catheter is coupled on its distal end to the pump housing and wherein the pump further comprises a drive cable extending through the elongate catheter.

Claims

1. A heart pump system comprising: a pump comprising a pump housing and a rotor, the pump housing having a proximal end and a distal end, and the pump being configured to be operated by a motor; a cannula comprising a proximal end and a distal end, wherein the proximal end of the cannula interfaces with the distal end of the pump housing; an elongate catheter extending proximal of the pump housing; one or more sensors, including a differential pressure sensor; and a controller configured to: receive a first data indicative of a time-varying motor current during a first period of time while the heart pump system is operating in a patient, wherein the time-varying motor current corresponds to an amount of current delivered to the motor; receive a second data indicative of a time-varying differential pressure measured by the differential pressure sensor during the first period of time, wherein the time-varying differential pressure corresponds to a difference in pressure between an inner portion of the heart pump system and an outside of the heart pump system and is further indicative of a position of the heart pump system relative to patient's heart; receive a third data indicative of time-varying motor current during a second period of time while the heart pump system is operating in the patient, wherein the second period of time is later than the first period of time; determine that the differential pressure sensor has failed when no data is received from the differential pressure sensor during the second period of time; and determine, in response to determining that the differential pressure sensor has failed, an estimate of time-varying differential pressure during the second period of time from the third data and a relationship between the first data and the second data, wherein the estimate of time-varying differential pressure during the second period of time is usable to predict the position of the heart pump system in the patient.

2. The heart pump system of claim 1, wherein the pump is configured to be placed such that the cannula extends across an aortic valve of the patient, the distal end of the cannula being located within a left ventricle of the patient, and the proximal end of the cannula being located within an aorta of the patient.

3. The heart pump system of claim 1, further comprising a flexible projection extending distally away from the distal end of the cannula.

4. The heart pump system of claim 1, wherein the elongate catheter is coupled on its distal end to the pump housing, and wherein the pump further comprises a drive cable extending through the elongate catheter.

5. The heart pump system of claim 1, wherein the controller is further configured to: provide a first indicator that the differential pressure sensor has failed; and provide a second indicator that the estimate of time-varying differential pressure during the second period of time is simulated.

6. The heart pump system of claim 1, wherein the controller is further configured to determine the time-varying differential pressure is drifting by: comparing the time-varying differential pressure to the estimate of time-varying differential pressure for the second period of time; calculating, based on comparing the time-varying differential pressure to the estimate of time-varying differential pressure, a difference between the time-varying differential pressure and the estimate of time-varying differential pressure over the second period of time; comparing the difference to a differential pressure signal threshold; and determining, based on comparing the difference to the differential pressure signal threshold, the difference is greater than the differential pressure signal threshold.