What is claimed:

1. A system for estimating a cardiac parameter of a patient based on a pre-determined model, the system comprising:

a blood pump comprising:

a rotor configured to be driven at one or more pump speeds; and

a sensor configured to measure a hemodynamic parameter; and

a controller comprising:

a driver configured to drive the rotor;

a display configured to display one or more parameters; and

a non-transitory computer readable storage medium storing:

a pre-determined model of a cardiac parameter, wherein the pre-determined model is formed by a neural network based on patient data for a first set of patients, wherein the patient data comprises measurements of at least one blood pump parameter for each patient in the first set of patients and measurements of at least one hemodynamic parameter for each patient in the first set of patients, wherein the neural network communicates over time in hidden states, and wherein the neural network iteratively develops the pre-determined model based on a plurality of activation functions; and

instructions that, when executed by one or more processors, cause the one or more processors to:

receive a hemodynamic parameter measurement for a second patient in a second set of patients from the sensor and record the hemodynamic parameter measurement;

receive a pump speed of the driven blood pump rotor from the driver and record the pump speed;

determine from the pre-determined model, based on the hemodynamic parameter measurement and the pump speed, an associated cardiac parameter; and

transmit the determined cardiac parameter to the display.

2. The system of claim 1, wherein the instructions further cause the one or more processors to determine a recommended change to the pump speed based on the determined cardiac parameter.

3. The system of claim 2, wherein the instructions further cause the one or more processors to transmit the recommended change to the pump speed to the display.

4. The system of claim 2, wherein the instructions further cause the one or more processors to make a change to the support provided by the blood pump based on the recommended change to the pump speed.

5. The system of claim 1, wherein the sensor is configured to measure at least one of aortic pressure, left ventricular end diastolic pressure, and capillary wedge pressure.

~~1. A method of estimating a cardiac parameter for a patient, the method comprising:~~

~~operating a blood pump within each patient in a first patient set, the blood pump having at least one measurable pump parameter;~~

~~measuring for each patient in the first patient set at least one hemodynamic parameter and the at least one measurable pump parameter to acquire a first hemodynamic parameter measurement and a first pump parameter measurement,~~

~~building a model of a cardiac parameter based on a relationship between the at least one first hemodynamic parameter and the at least one measurable pump parameter for the first patient set,~~

~~operating a second blood pump in a second patient in a second patient set; and~~

~~applying the model to the second patient by:~~

~~measuring the at least one measurable pump parameter in the second patient to acquire a second pump parameter measurement;~~

~~measuring the at least one first hemodynamic parameter in the second patient to acquire a second hemodynamic parameter measurement; and~~

~~estimating a cardiac parameter for the second patient, wherein the cardiac parameter for the second patient is output by the model based on the second pump parameter measurement and the second hemodynamic parameter measurement.~~

~~2.~~ 6. The ~~method~~ system of claim 1, wherein ~~measuring at least~~ each one of the measurements of the at least one hemodynamic parameter ~~comprises measuring the aortic pressure, and measuring the at least~~ for the first set of patients or each one ~~measurable~~ of the measurements of the at least one blood pump parameter ~~comprises measuring pump flow~~ for the first set of patients is obtained with a respective blood pump.

~~3.~~ 7. The ~~method~~ system of claim 1, wherein each one of the ~~method further comprising: inserting into each patient within~~ measurements of the at least one hemodynamic parameter for the first ~~patient~~ set of patients is obtained with a respective sensing catheter separate from ~~the~~ a respective blood pump~~; and measuring at the sensing catheter a measured cardiac parameter~~.

~~4.~~ 8. The ~~method~~ system of claim 1, ~~the method further comprising associating~~ wherein the pre-determined model is associated with patient information describing the first ~~patient~~ set of patients, and wherein the patient information comprises a diagnosis or a demographic for each patient in the first set of patients.

~~5.~~ 9. The ~~method~~ system of claim ~~4~~ 8, wherein the ~~method~~ instructions further ~~comprising determining~~ cause the one or more processors to determine whether the pre-determined model applies to the second patient based on the patient information associated with the pre-determined model.

~~6. The method of claim 1, the method further comprising computing a suggested change in a pump speed based on the estimated cardiac parameter in the second patient.~~

~~7. The method of claim 6, the method further comprising implementing the suggested change in the pump speed.~~

~~8. The method of claim 1, wherein building a model of a cardiac parameter comprises using a neural network to extract a model from the at least one first hemodynamic parameter and the at least one measurable pump parameter for the first patient set.~~

~~9.~~ 10. The ~~method~~ system of claim ~~8~~ 1, wherein the neural network comprises a plurality of cells, and wherein a first cell of the plurality of cells ~~comprising the neural network~~ accepts as inputs the measurements of the at least one ~~first~~ hemodynamic parameter and the measurements of the at least one ~~measurable~~ blood pump parameter for the first ~~patient~~ set of patients at a first time point.

~~10.~~ 11. The ~~method~~ system of claim ~~9~~ 10, wherein the first cell transforms the measurements of the at least one ~~first~~ hemodynamic parameter and the measurements of the at least one ~~measurable~~ blood pump parameter ~~based on one or more model fits,~~ before transmitting the transformed measurements of the at least one hemodynamic parameter and the transformed measurements of the at least one blood pump parameter to a second cell of the plurality of cells.

~~11. A method of estimating a cardiac parameter for a patient based on a model, the method comprising:~~

~~operating a blood pump in a patient;~~

~~measuring at least one measurable pump parameter of the blood pump in the patient to acquire a pump parameter measurement;~~

~~measuring at least one hemodynamic parameter in the patient to acquire a hemodynamic parameter measurement;~~

~~accessing from a database a model of a relationship between the at least one measurable pump parameter, the at least one hemodynamic parameter, and a cardiac parameter; and~~

~~estimating a cardiac parameter estimate for the patient, wherein the cardiac parameter estimate for the patient is output by the model based on the pump parameter measurement and the hemodynamic parameter measurement.~~

12. The ~~method~~ system of claim ~~11~~ 1, wherein ~~measuring~~ the at least one hemodynamic parameter ~~comprises measuring the~~ is an aortic pressure, and ~~measuring~~

wherein the at least one ~~measurable~~ blood pump parameter ~~comprises measuring~~ is a pump ~~flow~~ speed.

13. The ~~method~~ system of claim 12, wherein the cardiac parameter is one of a cardiac output, a cardiac power output, a stroke volume, or a compliance.

~~14. The method of claim 11, the method further comprising computing a suggested change in a pump speed based on the cardiac parameter estimated in the patient.~~

~~15. The method of claim 11, wherein accessing a model comprises choosing a model formed by a neural network.~~

~~2. A system for estimating a cardiac parameter of a patient based on a pre-determined model, the system comprising:~~

~~a blood pump comprising:~~

~~a drivable rotor, the rotor configured to be driven at one or more pump speeds; and~~

~~a sensor configured to measure a hemodynamic parameter; and~~

~~a controller comprising:~~

~~a memory configured to receive a hemodynamic parameter measurement from the sensor and record the hemodynamic parameter measurement, the memory also storing a pre-determined model of a cardiac parameter based on the hemodynamic parameter and a pump speed of the one or more pump speeds;~~

~~a driver configured to drive the rotor, the driver configured to transmit a pump speed of the driven blood pump rotor to the memory to be recorded;~~

~~a display configured to display one or more parameters recorded in the memory;~~

~~wherein the memory is configured to:~~

~~determine from the pre-determined model, based on the hemodynamic parameter measurement and the pump speed, an associated cardiac parameter, and~~

~~transmit the determined cardiac parameter to the display.~~

~~3. The system of claim 16, wherein the memory is configured to store a plurality of pre-determined models of the cardiac parameter based on the hemodynamic parameter and the pump speed.~~

~~4. The system of claim 17, wherein the plurality of pre-determined models are formed by a neural network which comprises a plurality of cells.~~

~~5. The system of claim 16, wherein the controller is configured to determine a recommended change to the pump speed based on the determined cardiac parameter.~~

~~6. The system of claim 16, wherein the sensor is configured to measure at least one of aortic pressure, left ventricular end diastolic pressure, and capillary wedge pressure.~~

14. The system of claim 1, wherein the neural network is a stacked bi-directional recurrent neural network.

15. The system of claim 1, wherein the neural network has three or more levels of cells stacked between an input row and an output row.

16. The system of claim 1, wherein the neural network is a fully recurrent neural network, an Elman network, a Hopfield network, an Echo state network, or a hierarchical neural network.

17. The system of claim 1, wherein the plurality of activation functions comprises a sigmoidal function.

18. The system of claim 1, wherein the plurality of activation functions comprises a hyperbolic tangent function.

19. The system of claim 1, wherein the plurality of activation functions comprises a sigmoidal function and a hyperbolic tangent function.