CardioSync: Real-Time PID Control of LVAD Hemodynamics

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Motivation

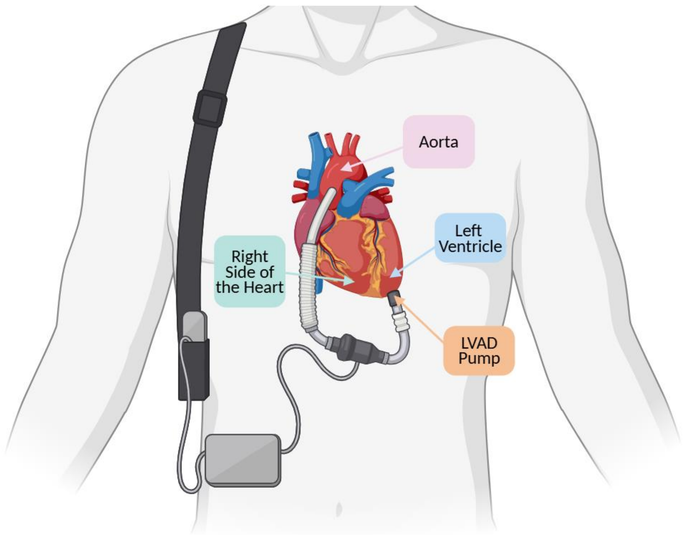

Fig. 1 Left Ventricular Assist Device (LVAD)

Current LVAD patients depend on clinicians to adjust pump RPM, which can lead to delays and inconveniences. Inaccurate speed settings can lead to serious complications, including suction events, thrombosis, hemolysis, and inadequate organ perfusion. LVAD mortality rates remain high, highlighting the need for improved control strategies.

Goals

- Develop a real-time, closed-loop control system for autonomous adjustment of LVAD RPM
- Minimize clinician reliance, reducing hospital visits and healthcare costs
- Improve patient independence and quality of life
- Maintain stable hemodynamic performance and reduce complications
- Reduce patient mortality

Economics

Current Market Size	~$2.5 Billion
2030 Market Size	~$3-6 Billion
Patent Licensing Value	$300,000-$500,000

Design and Methods

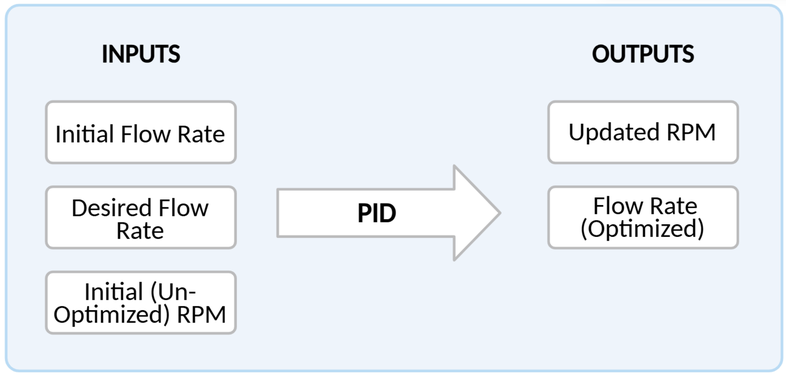

Fig. 2 PID Control Logic

A closed-system mock circulatory loop (shown right) was utilized for the tuning of the control algorithm (shown above), to ensure safe and correct speed transition. The components create a pressurized system in which blood simulant is pumped through branching tubing of alternating diameters, consistent with a cardiovascular network.

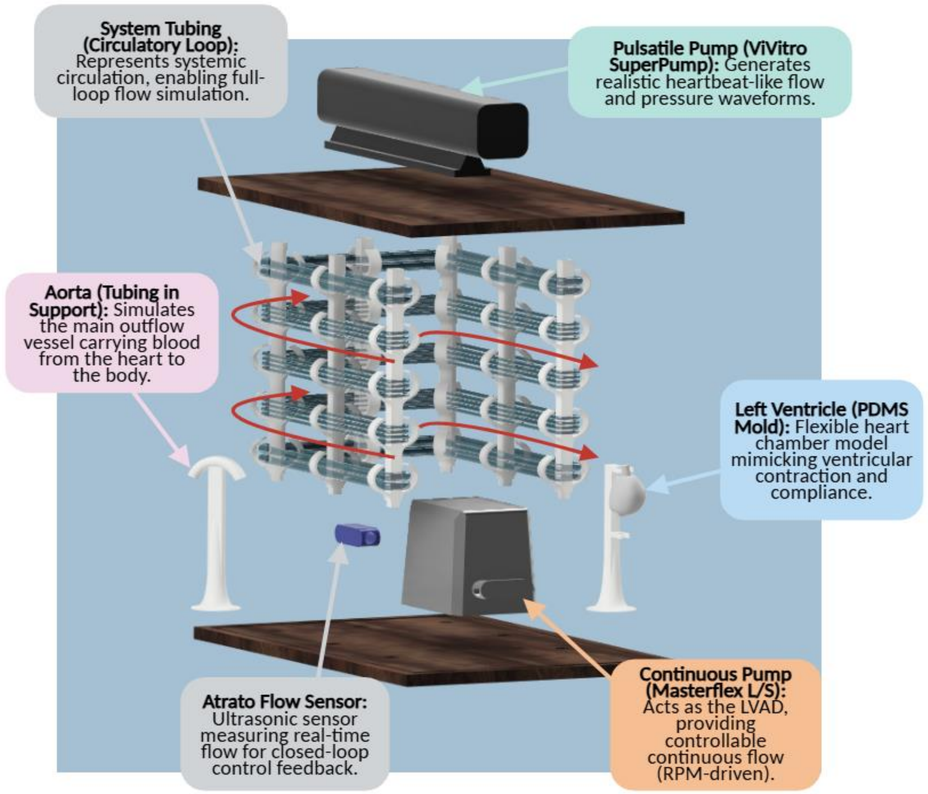

Fig. 3 Final LVAD Closed-Loop Flow System

Results

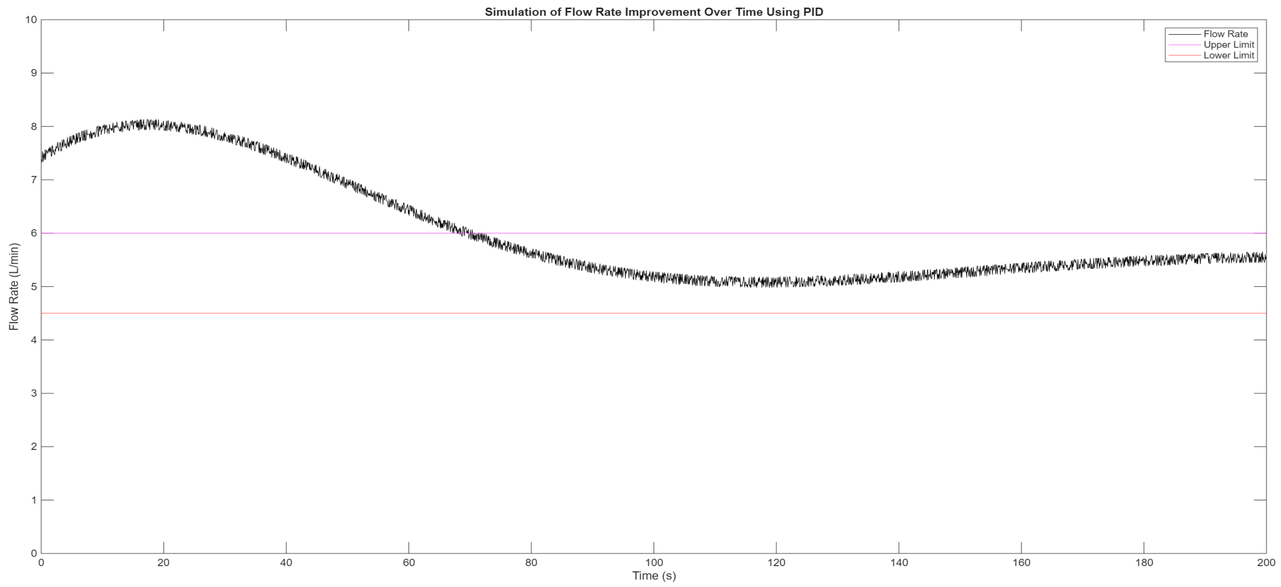

Fig. 4 Flow Rate Improved Over Time

This project improved flow rate (shown left) using a PID control algorithm to a predetermined goal over an approximate 3-minute period to ensure minimal thrombogenic formation risk by checking the flow rate several times per second to dynamically calculate the optimal RPM for the pump and slowly adjust over time.

Future Work

Transition to a microcontroller-based system, validate through physiological and clinical testing, integrate with LVAD systems, and pursue FDA approval and clinical deployment.

Acknowledgments

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