Computational Tools for **Growth Rate Calculation** in **Continuous Culture**

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Abstract

Turbidostat devices give experimenters control over stresses that microorganisms often adapt to, allowing researchers to better test their own mutated strains and how they adapt to specific applied stresses.

The Siegal Lab at NYU uses an open source turbidostat design from the Klavins Lab to study the evolution of yeast. Growth rate can be indicative of **fitness** and **adaptation** but previously we would have to measure growth rate through an independent experiment. We have since created automated **Python software programs** to dynamically estimate the growth rate of yeast in the continuous culture of the turbidostat, giving experimenters a real-time estimate of how their microorganisms are adapting to their environment.

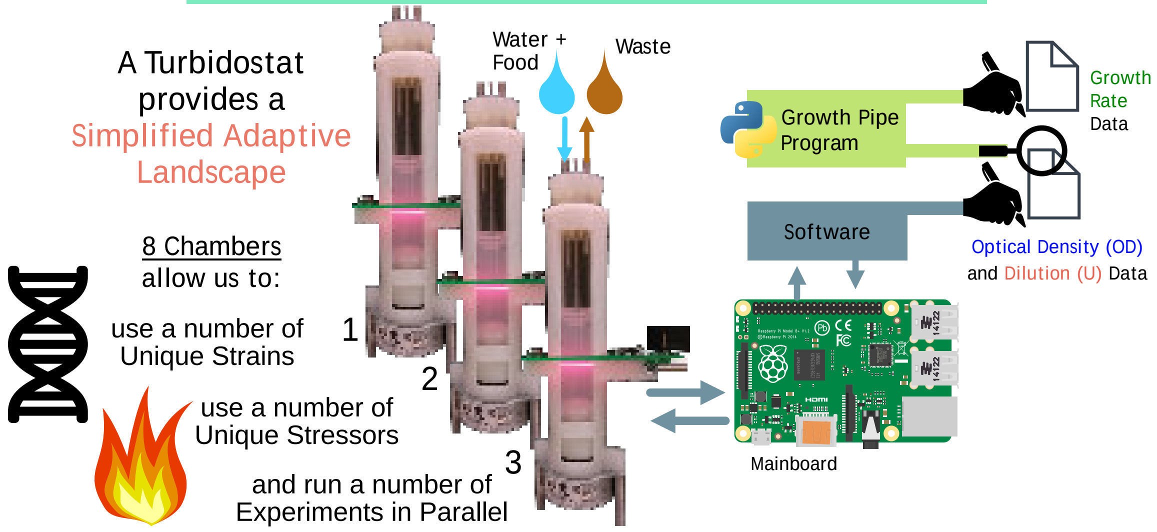
Open Source

Original hardware designs and source code:
Klavins Lab at University of Washington
Designs and Manual:
klavinslab.org/hardware

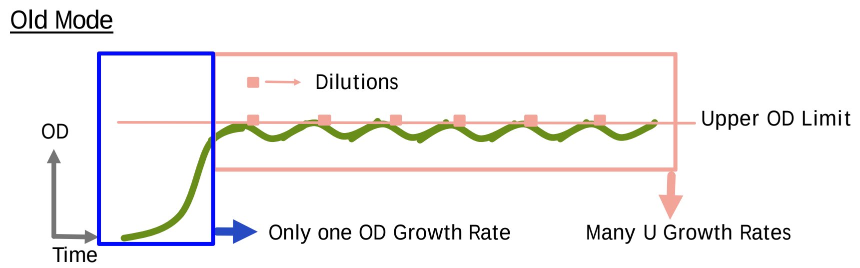
Contributions to source code:
Siegal Lab at NYU
Code:
github.com/Siegallab/Flexostat-interface

This Turbidostat is a licensed open source project, meaning:
- Free, publicly available hardware designs, software source code, and operating instructions
- Freedom to modify and redistribute

Experimental Setup

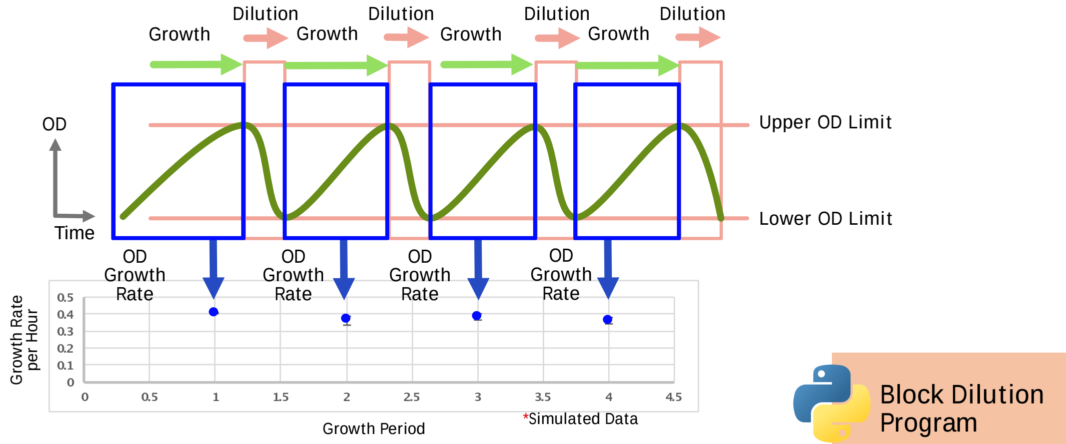


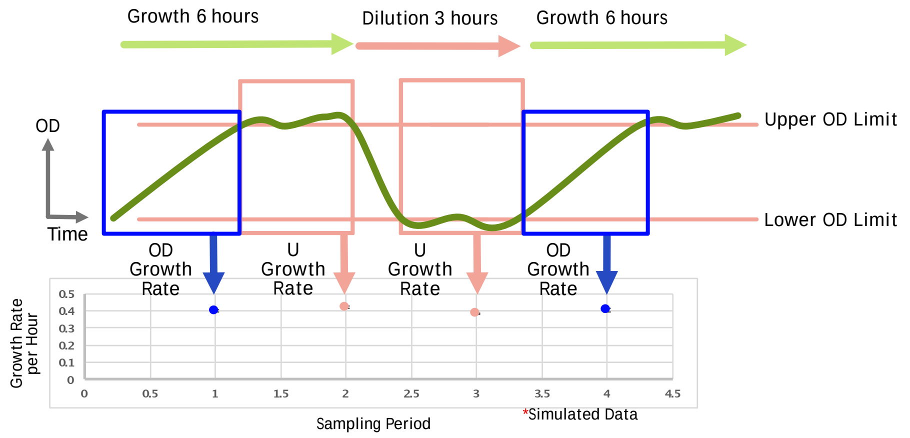
When a specific optical density has been reached, turbidostats dilute their growth chamber, **removing** some solution and **adding** some food and water. This decreases common stresses that microorganisms often adapt to such as high cell density, waste saturation, and limiting resources.



Previously, the turbidostat software did not compute growth so there was no way to estimate **fitness**. During an experiment it would also keep density near to the limit with repeated Dilutions (U), which can be used to calculate growth rate but are inaccurate. We developed an automated pipeline to continuously calculate growth rate and new modes to run experiments that allow for more growth rates based on Optical Density (OD), which are more accurate.

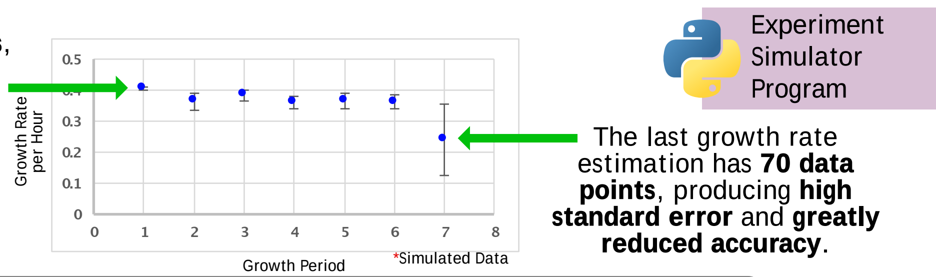
Estimating Growth Rate





Estimation Accuracy

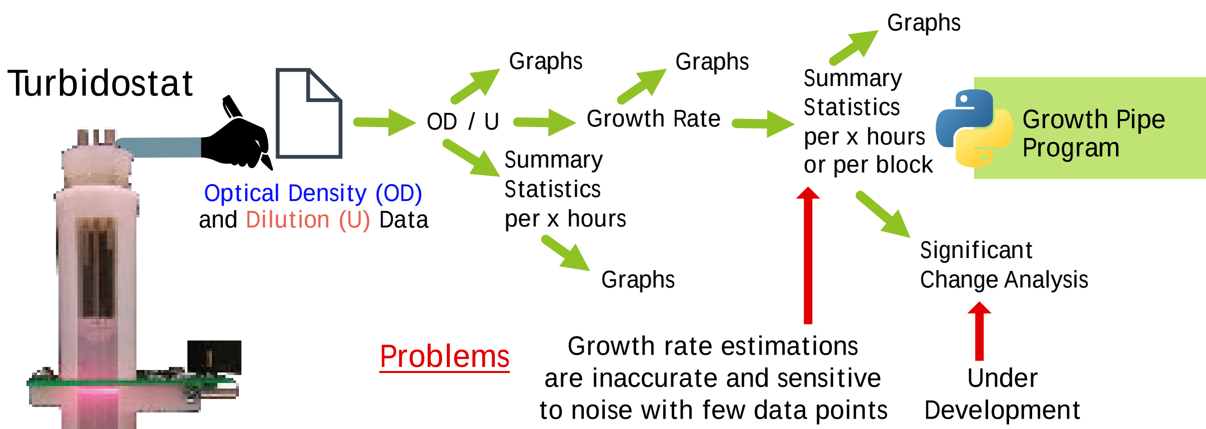
With **676 data points**, the first growth rate estimation is **very accurate** with **extremely tight standard error**.



The last growth rate estimation has **70 data points**, producing **high standard error** and **greatly reduced accuracy**.

A new program allows us to simulate experiments, producing hours worth of data in a few minutes. Here we simulate 0.4 per hour growth rate with noise, showing our analysis is only accurate when provided with enough data.

Computational Pipeline



Our pipeline can dynamically calculate **growth rates**, calculate **summary statistics**, and generate **graphs** for either Optical Density (OD) or Dilution (U) data. It is also highly configurable and easily automated.