1^{st} QTB PBR Hack‘a’thing

Soldering for and by beginners.

March 2–4, 2016

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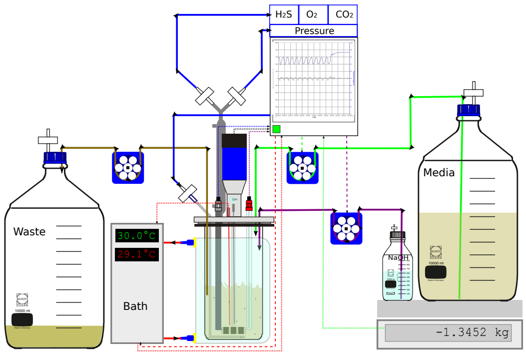
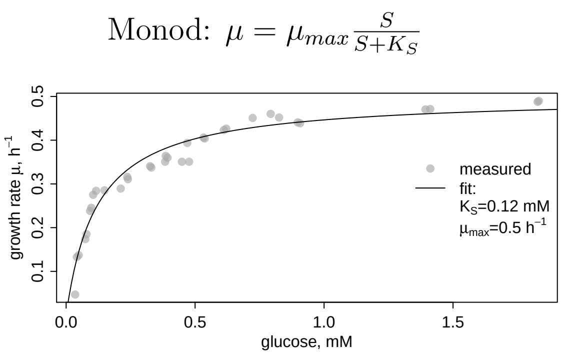


(a) Dougie's Reactor



(b) Snoep *et al.* 2009

Figure 1: Bioreactors

1 PBR Hack'a'thing Projects

1.1 Gas Flux: `Gas'o'meter`

Project: Extend existing setup, co2meter's O2 and CO2 sensors with Sainsmart's Arduino Mega+Touch screen

1. **code** sensor calibration routines via touch-screen (use PSI gas mixing system)
2. **build** water trap, tubing path from reactor, and casing for sensors and Arduino; **build** improved gassing system (glas blowers!) to allow lower flow
3. **build** & **code** interface to Aalborg XFM digital mass flow meter: connect the Aalborg's RS 485 interface to Arduino hardware serial Tx3/Rx3, and Ground
4. **build** & **code** valve control to measure several reactors; connect via Arduino software serial connections; perhaps attach to PSI Multicultivator

Ressources:

- Code in `offgas/arduino` of `https://git.hhu.de/machne/PSIControl`

Materials:

- Existing setup: **available**
- Aalborg XFM, with RS 485 interface: **available**
- Valve system for gas tubing, controllable *via* serial interface: **obtain**

1.2 Light Flux: Spectrometer

Project: Simple spectrometric measuring tool based on AvaSpec-Mini2048l-U25

1. Basic: Connect to Rasperry Pi, using drivers provides by Avantes; **code** simple interface with display and/or recording functions
2. Advanced: use LED for absorbance, reflectance, or fluorescence measurements; **build** light paths and perhaps a reactor probe for online recording

Materials:

- AVASPEC-MINI2048L-V25, Minispectrometer: **available**
- Fiber optic cables, VIS/NIR: 1 m, 200 µm VIS/NIR and 1m, 600 µm: **available**
- Raspberry Pi Version 1: **obtain**
- LED system: use PSI LEDs or **obtain**
- Reactor probe: **build** together with fine mechanics or glas blowers

1.3 Liquid Flux: Continuous Culture & Turbidostat

Project: build a module consisting of media and waste bottles, a reactor vessel, peristaltic pump(s), and a balance; pump and balance are controlled *via* serial interfaces from an Arduino+Touchscreen and/or Raspberry Pi. The flow rate is controlled *via* pump and recorded *via* the balance, flow rate (depends on culture volume) is recorded or can be set after a setup-specific (tubing) calibration routine

1. **build** a simple reactor vessel (Schott bottles) with liquid media flow, from media bottles through reactor vessel and out to waste bottle; connect *via* tubing and pumps
2. **code**: analog control of peristaltic motor speed and recording of weight loss and/or gain to record mass flow (g/min)
3. **code**: calibration routine to calibrate pump speed to weight loss/gain for a given setup
4. **build** & **code**: combine with 1.2 to make turbidostatic control
5. **build**: add gassing system of project 1.1 to make a first simple bioreactor

Ressources:

- using Arduino's PWM analog interface to control pump motor speed
- Arduino library for Elecrow weight sensor kit 3 kg
- HX711 24-Bit Analog-to-Digital Converter (ADC) for Weigh Scales

Materials:

- Media bottles, screw caps with inlet/outlet openings, and tubing: **available** & **obtain**!
- Balance - **obtain**
  fancy: Mettler Toledo, PBK785-3XS/f
  cheap: Elecrow Weight Sensor kit 3kg for Arduino
- Peristaltic pumps - **obtain**
  fancy: Longer Pump LP-BT100-2J, DG-2(10)
  cheap: Ismatec Ecoline VC-MS/CA4-12
  cheapest: Welco WPM
- Sainsmart Arduino Mega + Touchscreen - **obtain**

1.4 The Server

Project: a master software running on a (detachable) linux desktop that synchronizes and speaks via a comon interface to all Arduino and Raspberry Pi modules; the modules themselves can interpret get, set and act impulses (use arguments only when absolutely necessary).
During an initializiation the server may inquire what an attached module provides (*via* data IDs and SI units, meaningful time resolution) and handle it automatically.
Variable higher order control or processing logics can be built using defined data and control IDs.

1. **build** combine of gas (1.1), liquid (1.3) and light (1.2) modules into a bioreactor
2. **code**: master program to synchronize and record data from the three modules
3. **code**: combine e.g. 1.2 & 1.3 to implement turbidostat control

Materials:

- `setTime(time_t` t`)`: sets the current master time to all modules
- `get(..., time_t` t`)`: get all values, currently available (with a time stamp), or from a previous time t
- `act(..., time_t` t`)`: act (switch on and off, set to a specific value), now or at future time t

1.5 Heat Flux: Water Bath Thermostat

Project: build a water bath for growth vessels, control T, read-out energy required for maintaining constant T and estimate the amount of heat withdrawn or administered

1.

Materials:

- Jacketed reactor vessel: **build** or **obtain**
- Julabo water bath, e.g. F25-ME
- Arduino and/or Raspberry Pi

1.6 The `Kaiten Eppi`: Automated Sampling Device

Projects: build sterile and automated sampling device; using a controllable syringe pump, sampling into the `Kaiten Eppi` (automated: pump sample into tubes, potentially pre-filled with chemicals, vortex, and transport them into liquid N_2 or other storage containers)

Materials:

- Sterile sampling device by HHU glas blowers: **available**
- Syringe pump: **obtain**
- `Kaiten Eppi`: **build**
- Sainsmart Arduino Mega & Touchscreen: **obtain**

1.7 Single Cell Biology: Microfluidic Device

Project: Basic microfluidics and live-cell imaging device; scratch growth chambers and liquid flow channels into microscope slide; attach 2–3 pumps; and control *via* arduino/screen

Materials:

- Ilka's lab microscope: **available**
- Microscopy slides: **available**
- 2–3 peristaltic pumps for microfluidics: **obtain**
- Sainsmart's Arduino Mega + Touchscreen: **obtain**

2 Program

2.1 Day 1 <12:00 : Building Bioreactors

Talks, 30-60 min:

- Rob's DIY Reactor - The Beginnings: The Captor - Arduino-controlled mini PBR
- Dougie's DIY Reactor - 20 yrs Later
- Avantes - Spectrometry: Spectrometry applications, incl. NIR for metabolite measurements and OD; software interface to Avantes spectrometers
- CellDeg - Optimizing Photosynthetic Growth: Introduction to CellDeg's 2.5 k Euro algal growth setup (overnight 30 g/L cyano biomass)

2.2 Day 1 >13:00 : Hack'a'thing I

- Introduction to the `Gas'o'meter`: connecting sensors with Arduino, making an autonomous measurement device via Sainsmart's Touch Screen
- Introduction to Rob's reactor: complete setup for photosynthetic growth
- Self-organizing into teams: lab hardware (tubing etc.), control hardware (soldering etc.), software and/or by by projects (1.1–1.7)

2.3 Day 2 : Hack'a'thing II

- Hardware I: soldering, tubing
- Software I: probe/sensor/pump ⇔ arduino/raspi interfaces
- Visit HHU's fine mechanics and glas blower work-shops, place orders for stuff missing for above goals

2.4 Day 3 : Hack'a'thing III

- Hardware II: Integrate projects 1.1,1.2&1.3 into a simple DIY reactor and/or with PSI FMT150 or Multicultivator
- Software II: arduino/raspi ⇔ master/server interface
  Standard data formats and interfaces
- Brain storming: relation of data and models and beer

3 Outlook: 2^{nd} QTB PBR Hack‘a’thing

3.1 Growth Dynamics: Photobioreactors in Research

Talks, 30-60 min:

Nir Keren, Hellingwerf, Jan Cerveny, Dougie Murray, something microfluidics?

3.2 Single Cell Dynamics: Microfluidic Devices

Integrate project 1.7 with the simple microscope in Ilka’s lab, or a more advanced system (CAi?)

3.3 Omics: Sterile and Automated Sampling Devices

Proper sampling for high-throughput data (mass spectrometry, sequencing) acquisition