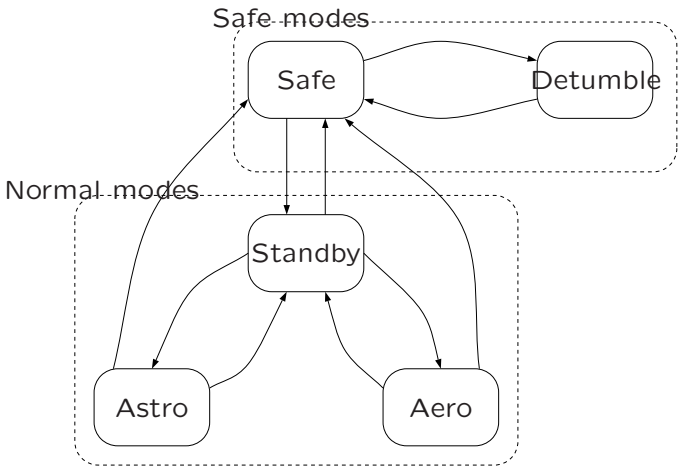
A control perspective

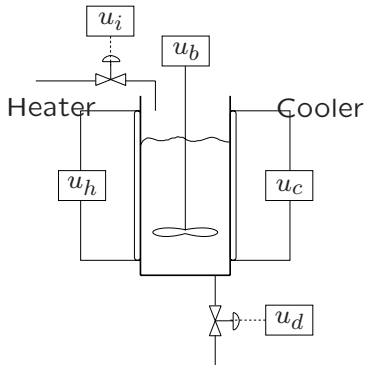
- stability
- synthesis

- Different operating regions
  - Aircraft (JAS)
- Continuous plant controlled by a switching controller,
  - Satellite (Odin)
- Continuous system controlled by discrete controller
  - Chemical reactor

Example: Satellite



Example: A chemical reactor



Linearized system model

$$\dot{h} = -a_h u_d h + b_h u_i$$
$$\dot{T} = -(a_{T_1}(1-u_b) + a_{T_2} u_b)T + b_{heat} u_h + b_{cool} u_c + b_{reac} u_r$$

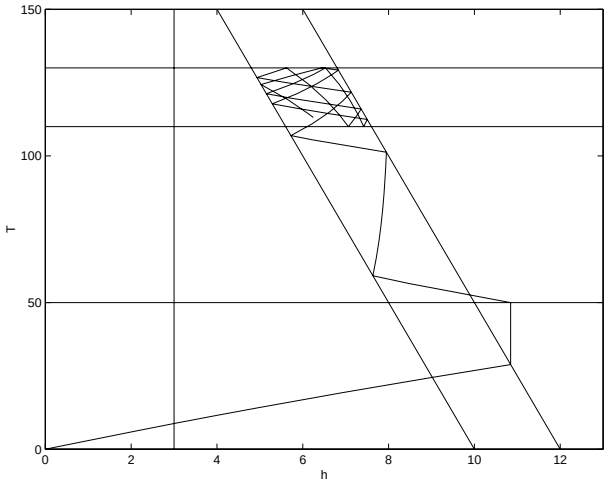
where $u_d, u_i, u_b, u_h, u_c, u_r \in \{0, 1\}$.

The variable u_r tells whether the reaction has started; it equals zero when $T < 50$ and one otherwise.

Control design

- *Heater*, u_h: The heater is on when the temperature is below 50 and off otherwise.
- *Cooler*, u_c: The cooler is off while the temperature is below 130, then it is turned on. It stays on while the temperature is above 110.
- *Blender*, u_b: The blender is off when the fluid level is below 4 and on otherwise.

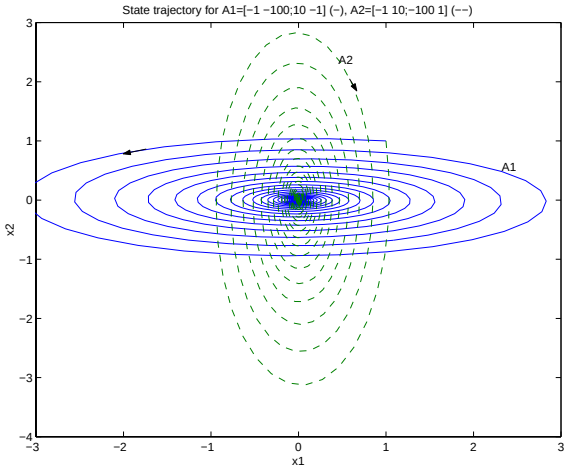
- *Draining*, u_d: The drain valve is closed when the temperature is below 50 and open otherwise.
- *Inflow*, u_i: The inflow valve is open while the fluid level is below the line γ_3, then it is closed. It stays closed while the fluid level is above γ_2.



Stability

- Continuous plant, switching controller
- Even if the different controllers by themself stabilizes the system, the resulting system can be unstable and vice versa!
- Not easy to analyze stability!
- DeCarlo et.al.

Example



Synthesis: Avoid "bad states" - safety specifications

- Given hybrid automata, find when and how to switch (Asarin et.al.)
- Reachability analysis to avoid "bad" states (Asarin et.al., Tomlin et.al.)
- Abstracting the continuous part $\Rightarrow$ Ramadge-Wonham DEDS - safety spec. (Koutsoukos et.al.)

Synthesis: optimal control

- Manufacturing - given schedule find optimal control (Pepyne et.al.)
- More general (Bemporad et.al.)

Analysis:

- Benefits of switching controllers (McClamroch et.al.)