Control Theory for SRE

Using PID Controllers to scale your services smoothly

2 October 2019

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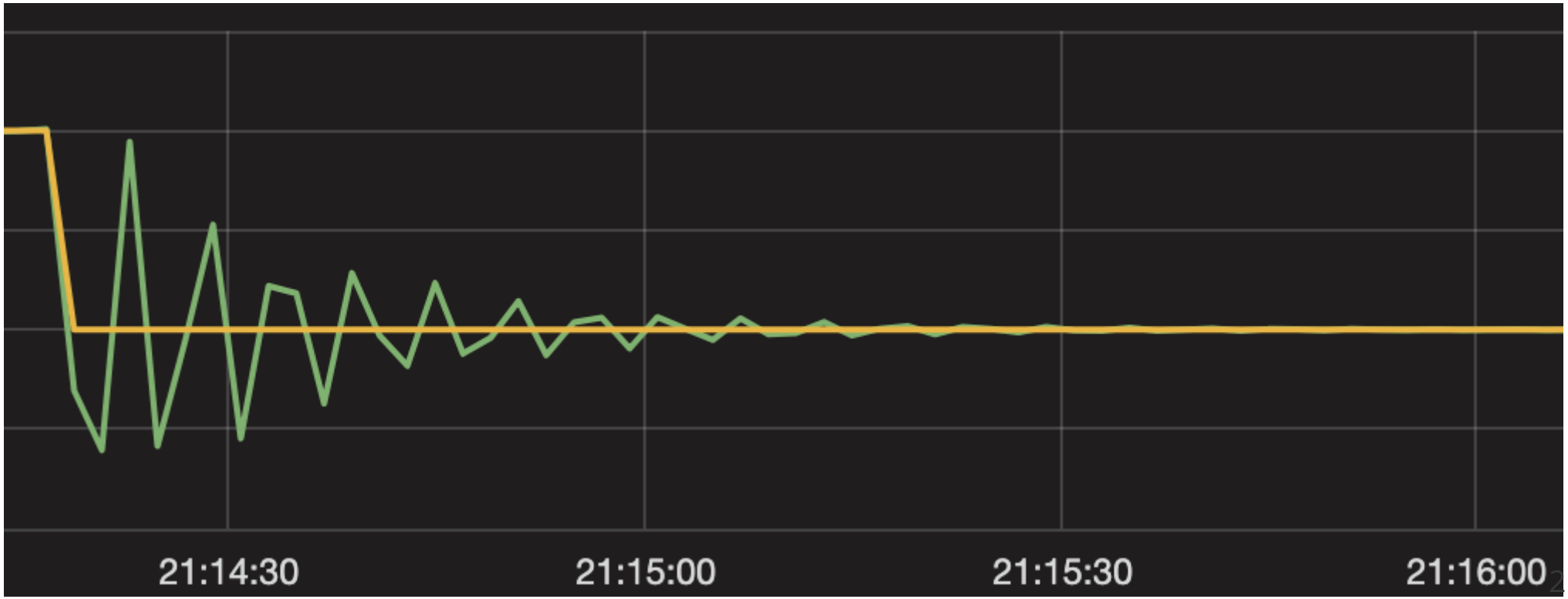
Control Theory For SRE



History of Control Theory

- What is a PID controller? Why use one?
- Steam Engines and Centrifugal Governors
- Cruise Control in your Car
- Ship Steering

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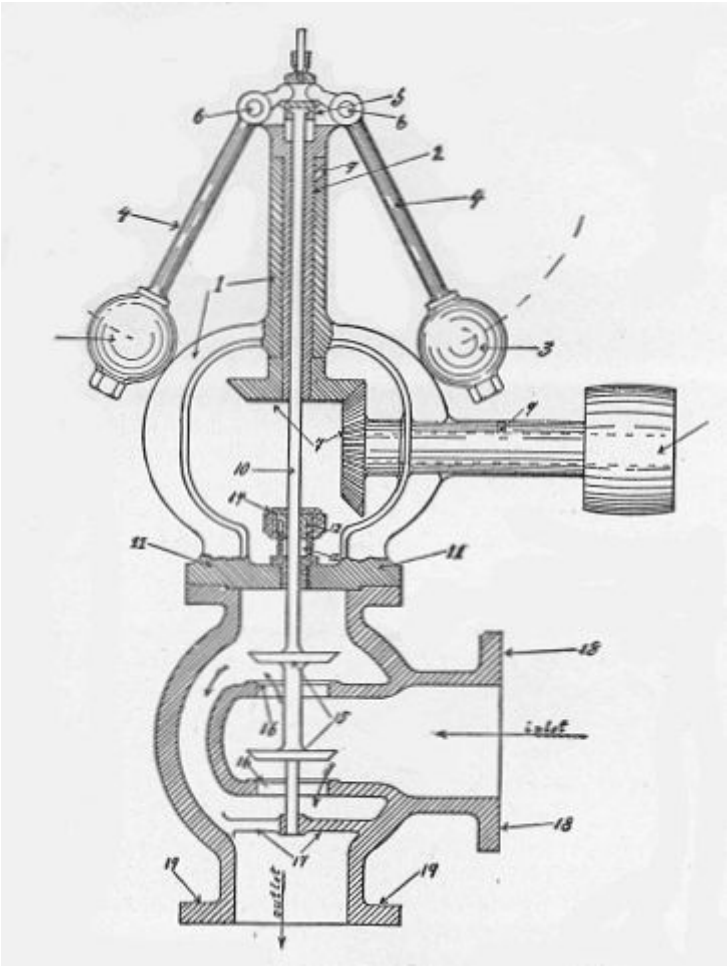
Centrifugal Governor - Ealiest application.

A Centrifugal Governor (https://en.wikipedia.org/wiki/Centrifugal_governor) is one of the earliest examples of a PID controller.



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"The possibility of obtaining more accurate steering by automatic means than can be accomplished by manual control with its inherent limitation due to the low sensitiveness of the human eye in dectecting slow angualr motions, fatigue, etc., becoms of greater importancw ithe increase in size of ships and cost of fuel"

- N. Minorsky, Directional Stability of Automatically Steered Bodies, May 1922

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Math of a PID controller

Error at time *t*:

e(t) = SP - PV

$$u(t) = K_\mathrm{p} e(t) + K_\mathrm{i} \int_0^t e(t')\,dt' + K_\mathrm{d} \frac{de(t)}{dt},$$

Diagram from https://en.wikipedia.org/wiki/PID_controller#Mathematical_form (https://en.wikipedia.org/wiki/PID_controller#Mathematical_form)

PID Math in Prometheus

```
- record: control_terms_kp
  expr: avg(control_kp) * pid2d_error
- record: control_terms_ki
  expr: avg(control_ki) * sum_over_time(pid2d_error[10m])
- record: control_terms_kd
  # The d term is extrapolated out to the same window as the Ki term
  expr: avg(control_kd) * idelta(pid2d_error[1m]) * count_over_time(pid2d_error[10m])
```

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PID Math in Prometheus

```
- record: pid2d_location
  expr: (pid2d_location + pid2d_velocity) or vector(0)
- record: pid2d_error
  expr: avg(control_setpoint) - pid2d_location
```

```
- record: pid2d_deltav
  expr: clamp_min(clamp_max((control_terms_kp + control_terms_ki + control_terms_kd), 100), -100)
- record: pid2d_velocity
  expr: (pid2d_velocity + pid2d_deltav) or vector(0)
```

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Introducing the technologies

- Prometheus
- Grafana
- Controller
- Kubernetes

Demo - A simple PID Controller.

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Tuning a PID controller

- Hand tuning
- Ziegler-Nichols Method https://en.wikipedia.org/wiki/Ziegler%E2%80%93Nichols_method (https://en.wikipedia.org/wiki/Ziegler%E2%80%93Nichols_method)
- Damping
- Other methods

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About this talk

The source for this presentation can be found at gitlab.com/gauntletwizard/pid-controller-talk (https://gitlab.com/gauntletwizard/pid-controller-talk)

The presentation itself is available online at pidtalk.kube.gauntletwizard.net/presentation.slide (http://pidtalk.kube.gauntletwizard.net/presentation.slide)

Areas for further work:
- Add more explanation to this respository
- Build a Kuberenets Model

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References:

- S. Bennett, "A brief history of automatic control," in IEEE Control Systems Magazine, vol. 16, no. 3, pp. 17-25, June 1996. doi: 10.1109/37.506394 (https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=506394)
- N. Minorsky, "DIRECTIONAL STABILITY OF AUTOMATICALLY STEERED BODIES," in American Society of Naval Engineers, doi: 10.1111/j.1559-3584.1922.tb04958.x (https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1559-3584.1922.tb04958.x)

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Thank you

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