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System Identification and Control Synthesis of a Stormwater Catchment

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August 23, 2017

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Outline

* Introduction to dynamic stormwater management
* Case study in Lenexa, Kansas
* Proposal goals

Kevin Smith

Opti

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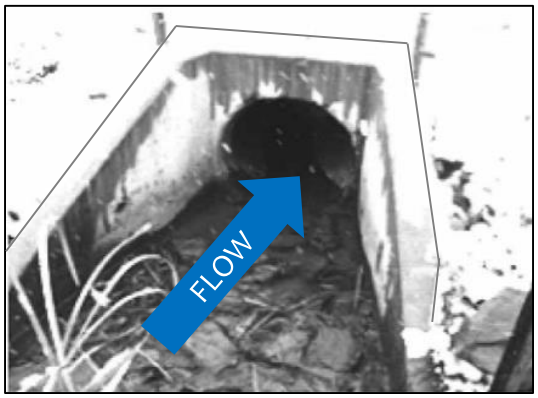
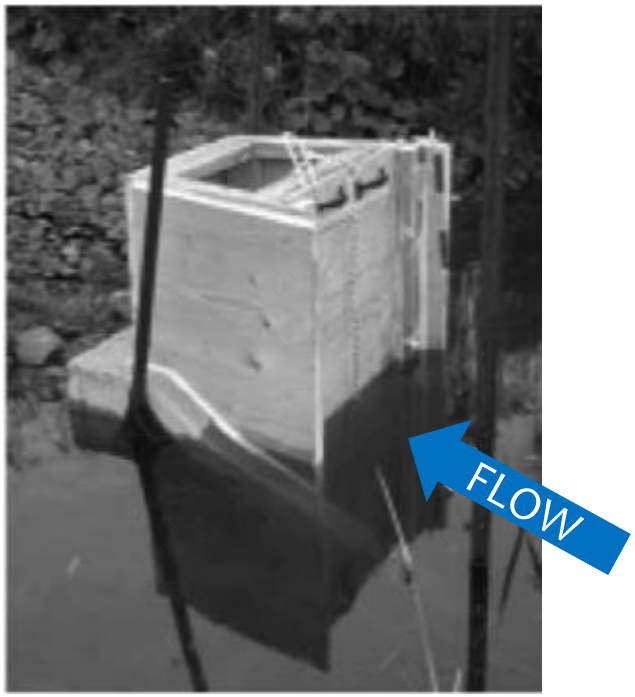
Passive vs. Active Control



Passive pond outlet



Active pond outlet

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Carpenter *et al.* 2014

Rationale for passive stormwater management

Economics

Weather uncertainty

Decentralized organization

Long lifetime

Regulatory context

Rationale for Active Stormwater Management

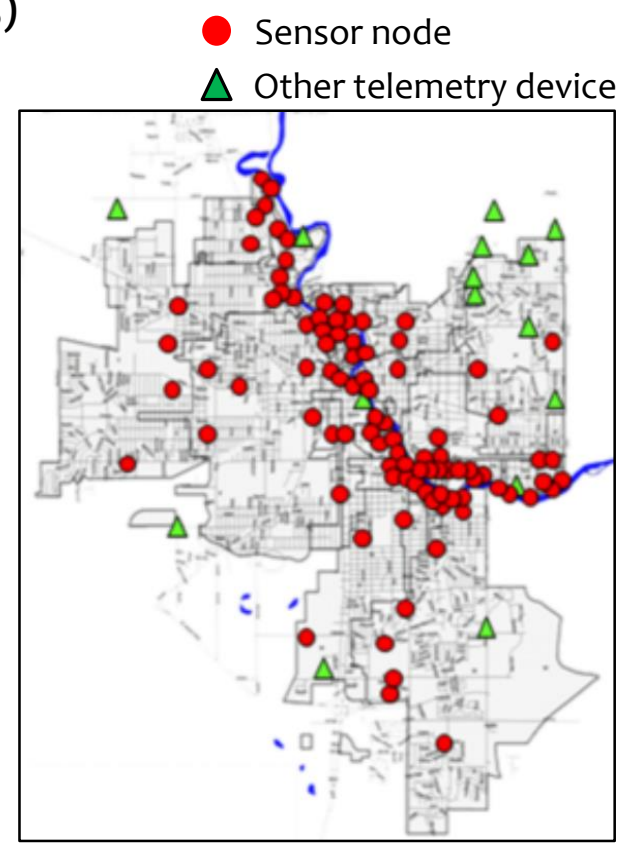
* Improve water quality (Klenzendorf *et al.* 2015, Middleton & Barrett 2008, Mullapudi *et al.* 2017)

* Protect aquatic ecosystems (Montestruque & Lemmon 2015)

* Enhance water supply (Rohreh & Armitage 2017, Drumheller *et al.* 2017)

Challenges of Active Stormwater Management

* Regulatory compliance (Klenzendorf *et al.* 2015)
* Economics (Poresky *et al.* 2015)
* Decentralized organization
* Security of cyber-physical systems (Amin *et al.* 2013)
* Weather & hydrologic uncertainty



Sensor network (South Bend, IN) (Montestruque & Lemmon 2015)

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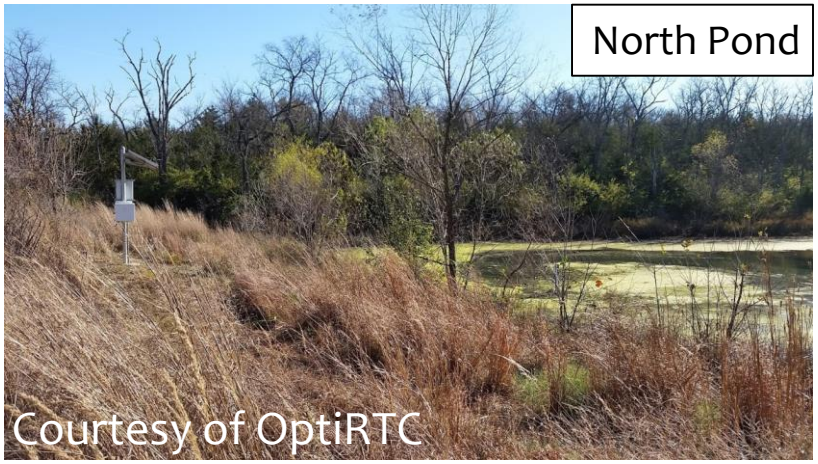
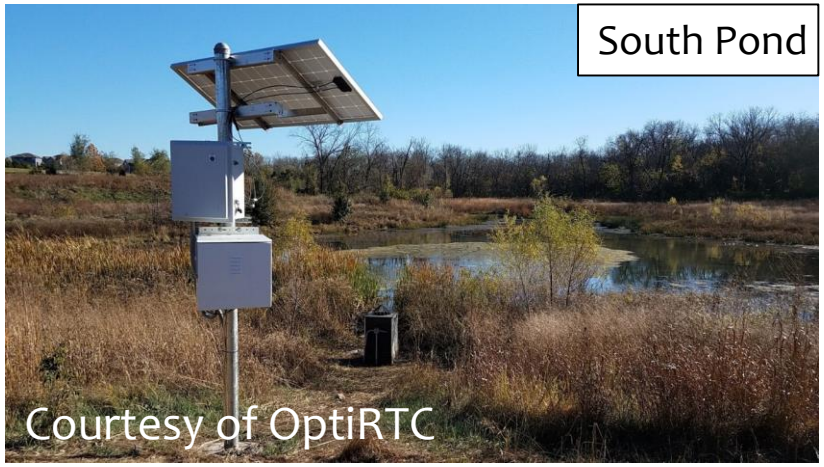
Case study: Lenexa, Kansas





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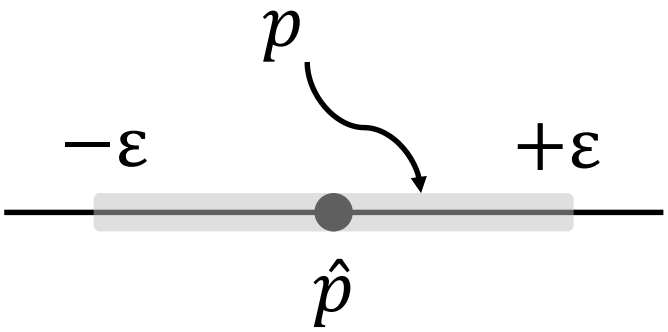
Available data, sensors, & control inputs

Predicted disturbance	40 h of precipitation forecast from National Weather Service (updated hourly)
Estimate of true disturbance	Post hoc rain data from local airport
Model parameters	Estimates of static geometry and hydraulic coefficients
Near real-time measurements	Pond stage
Control inputs	Pond outflow rate (every minute)

Proposal details

1. Identify hydraulic model
2. Review strategies for measuring & modeling rainfall
3. Examine effects of error on hydraulics
4. Synthesize controller robust to rainfall uncertainty
5. Implement robust hybrid MPC controller *in silico*
6. Evaluate controller performance
7. Make software accessible
8. Explore practical implementation

#3 Examine effects of error on hydraulics



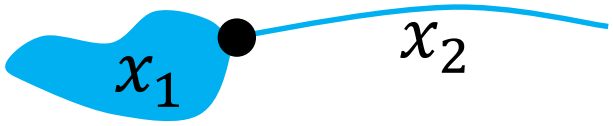
$\hat{p}$: forecasted

p : true

ε : uncertainty

} # inches rainfall on [0, 6h]

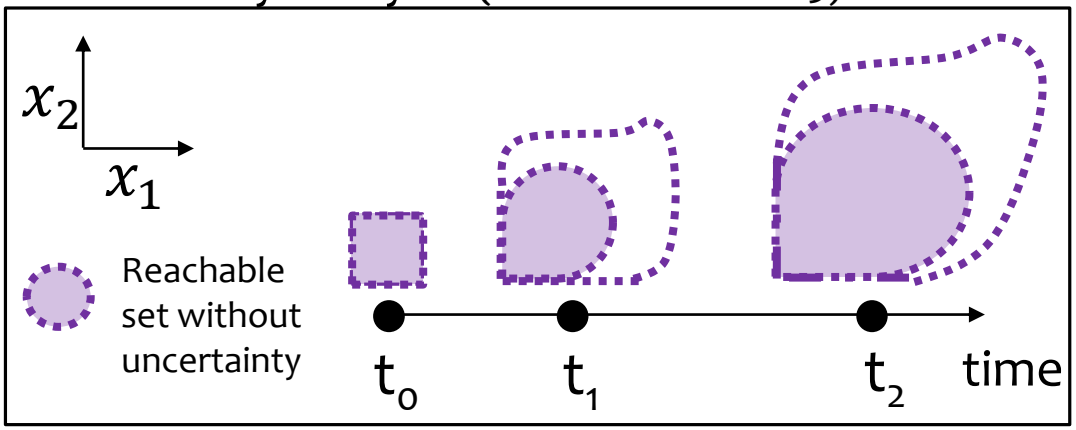
Part of catchment



x_1 = water volume, north pond

x_2 = water volume, north stream

Reachability analysis (Mitchell *et al.* 2005)



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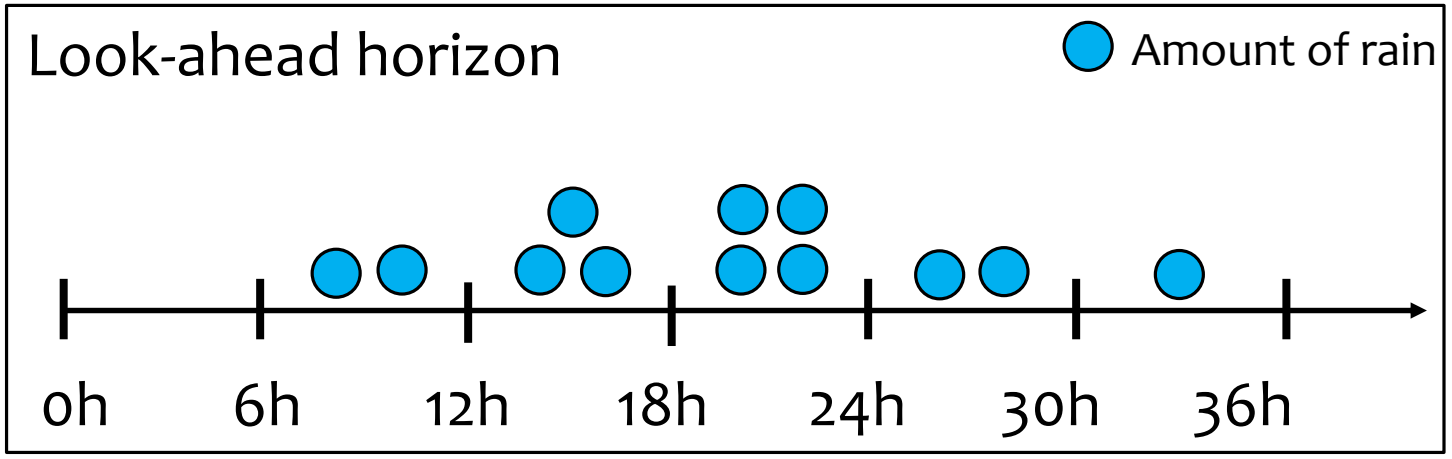
#4 Synthesize a robust controller

* Robust model predictive control
* Performance measure (regulatory criteria)
* Examine long-term value



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Timeline

(1) Construct hydraulic model

(2) Review strategies for measuring & modeling precipitation

(3) Examine effects of errors in precipitation on system response.

(4) Synthesize a controller that is robust to precipitation uncertainty.

(5) Implement controller in MATLAB

(6) Evaluate controller performance

(7) Software development

(8) Real implementation

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