BRADLEY University

TeeJet TECHNOLOGIES

TeeJet Adaptive Controls Research Project – 2020
Project Statement

Model-Free Adaptive Flow Rate Control of Heterogeneous Agricultural Spraying Machines

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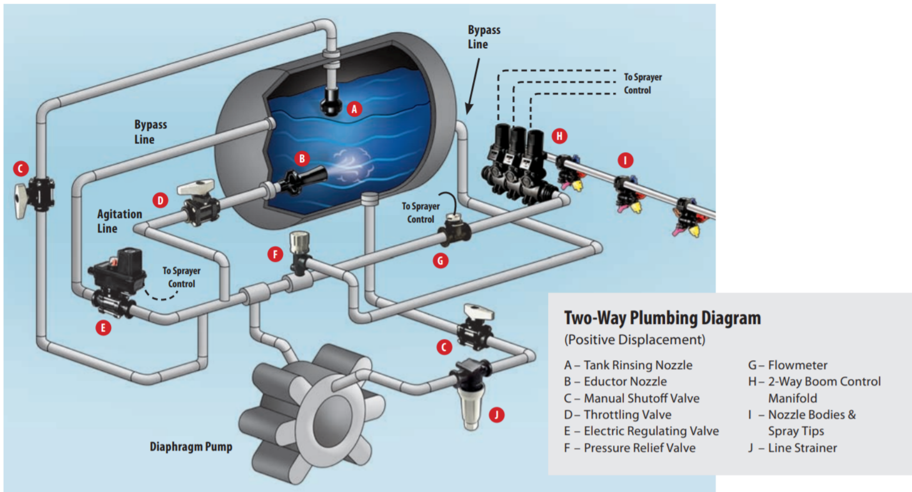

Figure 1: Two-way plumbing diagram of an agricultural srayping machine [Courtesy of TeeJet Technologies].

List of Abbreviations

PWM Pulse Width Modulation

1 Background

Agricultural Spraying machines are used to apply chemical to farmland to increase the productivity of the land. Fertilizer increases yield by 40% to 60%. If pesticides are not used, yield decreases by 50% to 90%. To maximize these yields, the correct amount of chemical must be applied to the correct area of the plant or soil. Chemical is applied using sprayers which are connected to a pump through plumbing system. A two-way plumbing diagram of an agricultural spraying machine is shown in Figure 1.

Illustra this figure

2 Problem Statement and Objectives

All sprayers have a pump that forces chemical from a tank through hydraulic plumbing leading to the boom of the sprayer (see Figure 1). Flow to the boom can be changed by either changing the speed of the pump or by opening and closing a regulation valve.

Across the boom are a number of nozzles that serve as the exit point for fluid. These nozzles also have a solenoid that can open or close the valve. By applying a PWM signal, we can When spaying, the farmer is limited to how fast he/she can drive and apply the correct amount of chemical without increase. In a sprayer application, we have two separate discrete-time feedback control systems to solve these problems.

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1. One system controls to a desired flow rate. This system ensures the correct amount of fluid is applied to the field. Target flow is calculated by the prescription for the field and the speed of the vehicle.

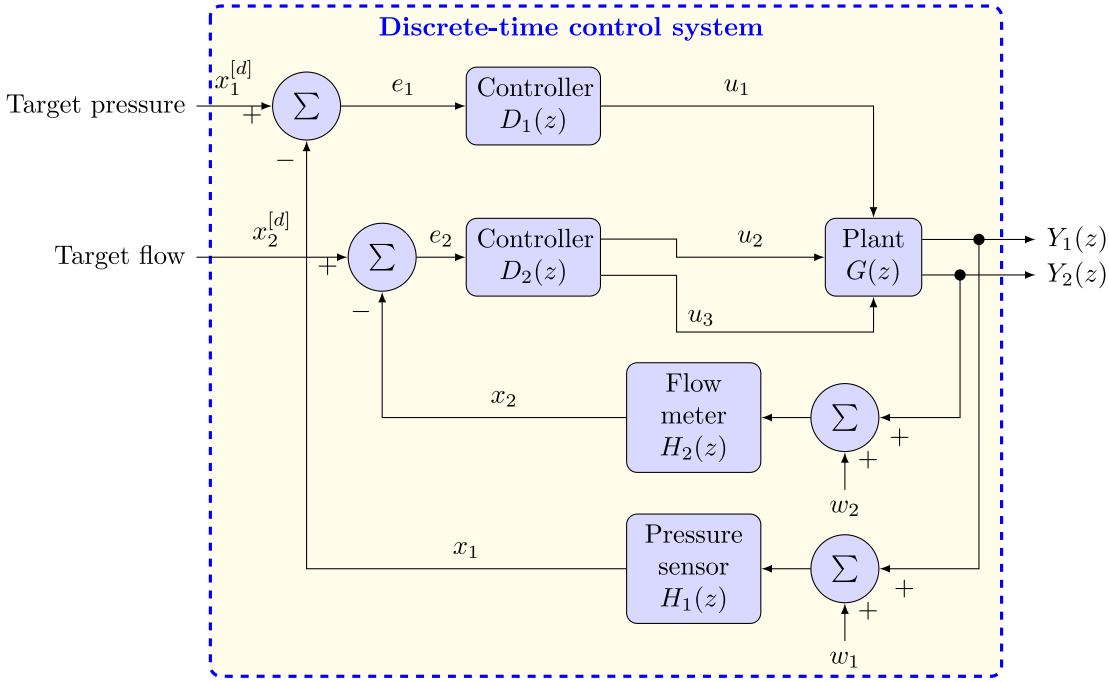

Figure 2: Two-input, two-output discrete-time control system block diagram.

2. A second system controls to a constant pressure across the boom of a sprayer. Droplet size directly correlates to pressure and can be determined from the nozzle's datasheet. This ensures proper application of the fluid and prevents drift due to atmospheric conditions.

Flow rate controllers, pressure controllers, and sprayers can all be manufactured by different companies. This makes it very difficult to come up with a design that will ~~preform~~ perform well across different scenarios. Figure 2 shows the block diagram of a two-input two-output discrete-time control system block diagram, where $D_2(z)$, $G(z)$, $x_2^{[d]}$, and x_2 are assumed to be unknown.

Problem statement: Develop a control system that can adapt to different plant models and rate controllers.

Do you mean flow rate and target pressure controllers?

Outcomes:
TeeJet expects design of a control system that can adapt to:

1. Different plant models
2. Different rate controllers

Student experience are expected to learn the following items that pertain to proposed control system:

1. Design the control system that is ready for implementation
2. Conduct computer simulations using MATLAB and Simulink
3. Validation and testing using real-time embedded system

Table 1: Description of signals used in the control system block diagram shown in Figure 2.

Signal	Description
$x_1^{[d]}$	Target pressure
$x_2^{[d]}$	Target flow
x_1	Actual pressure
x_2	Actual flow
$D_1(z)$	Pressure controller transfer function
$D_2(z)$	Flow controller transfer function
u_1	Duty cycle to solenoids (limited between 0 and 100)
u_2	Open/close signal for regulating valve
u_3	Pump speed (optional)
$G(z)$	Plant model
$H_1(z)$	Pressure sensor model (transfer function)
$H_2(z)$	Flow meter model (transfer function)
w_1	Pressure sensor noise
w_2	Flow meter noise

3 Solution Approach

Model-Free Reinforcement Learning Control Approach

4 Deliverables

TBD

5 Timeline and Milestones

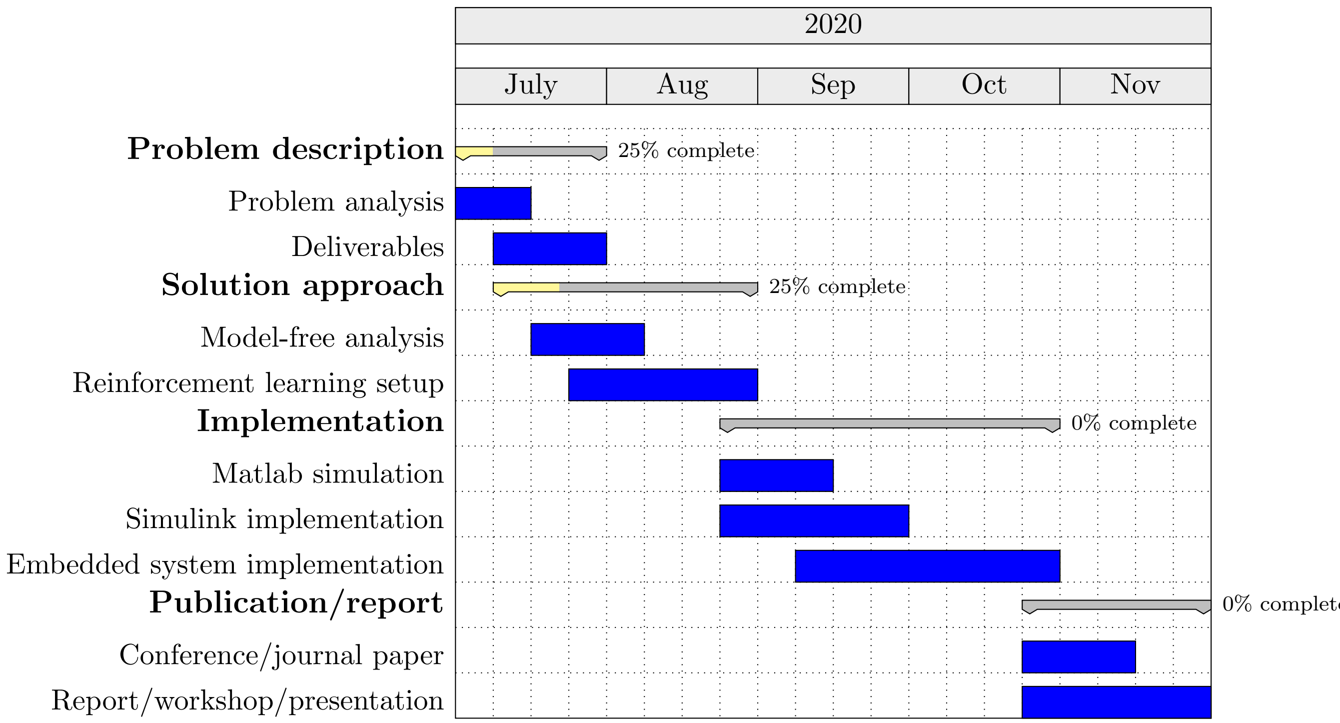

Figure 3: Gantt chart showing the project activities from July 2020 to November 2020.