SC42025 FILTERING AND IDENTIFICATION

TURBULENCE MODELING FOR ADAPTIVE OPTICS

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Contents

INTRODUCTION

This assignment deals with modeling an *Adaptive Optics* (AO) system in which three different data-driven turbulence modeling methods are used to achieve optimal control performances, viz.

- a random-walk process
- a Vector-Auto-Regressive model
- a stochastic state-space model

Each model has some questions associated with it, and we solve them in chronological sequence taking one model at a time.

1. RANDOM WALK MODEL

Question 1

We know from the assignment's equation (2) that:

$$s_o(k) = G\phi(k) + e(k)$$

We have the values of the wavefront sensor data in open-loop, $s_o(k)$, and also the value of the matrix G. To compute the value of $\phi(k)$, given no prior information on it, we follow the linear least-squares approach:

$$content...$$

Question 2

We are provided with some prior information about the wavefront, viz.:

- E[ϕ(k)] = 0
- E[$\phi(k)\phi(k)^T$] = $C_\phi(0)$
- noise variance = σ_e^2

Based on equation (8) from the assignment, we approximate the value of $C_\phi(0)$ as:

$$C_\phi(0) = \frac{1}{N}\sum_{i=1}^{N}\phi(i)\phi(i)^T$$

WE HAVE THE REQUIRED DATA NOW WE JUST NEED TO COMPUTE THE EXPRESSIONS. Pg 113 in book

For questions 3 to 5, we assume E[$\epsilon(k)$] = 0 and E[$\epsilon(k)\epsilon(k)^T$] = $C_\phi(0)$

Question 3

Similar to previous question but with now closed loop expression for s(k).

Question 4

Use an expression similar to Kalman Gain to get ideal predictor.

Question 5

Find Optimal Increment.

2. VAR Model

Question 1

We know from the assignment's equation (2) that:

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We have the values of the wavefront sensor data in open-loop, $s_o(k)$, and also the value of the matrix G. To compute the value of $\phi(k)$, given no prior information on it, we follow the linear least-squares approach:

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