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| Ex. No.:12 | **Test of Controllability and Observability in Continuous and Discrete Domain in Simulation Platform.** |
| Date: |

**Aim**

To Test Controllability and Observability for the given state model representation of system in simulation platform.

**Introduction**

Controllability:

A system is completely controllable if the initial state of the system is transferred to any particular state, in a finite time duration, when a controlled input is provided to it.

There are several ways to test for controllability, including the Kalman test and the Hautus test. The Kalman test checks if the controllability matrix is of full rank, while the Hautus test checks if the eigenvalues of the matrix are all nonzero. In general, these tests are performed in the frequency domain and are used to generate a controllability Gramian, which is a measure of the effectiveness of the control inputs in steering the system towards a desired output.

It is important to note that while these tests are useful in determining controllability, they do not guarantee that a system is controllable. Other factors, such as system noise and disturbances, can also affect the controllability of a system. The rank of the quadratic form is equal to the number of non-zero Eigen values of the matrix of quadratic form.

Observability:

Observability of a control system is the ability of the system to determine the internal states of the system by observing the output in a finite time interval when input is provided to the system.

There are several ways to test for observability, including the Kalman test and the Hautus test. The Kalman test checks if the observability matrix is of full rank, while the Hautus test checks if the eigenvalues of the matrix are all nonzero. These tests are important because they allow us to determine whether a system is observable before we try to control it. The rank of the quadratic form is equal to the number of non-zero Eigen values of the matrix of quadratic form.

**Procedure**

Step1: Obtain the state space model matrix of the system.

Step2: Determine Qc using formula

Qc = [B AB A2 B ……. An-1 B]

Step3: Check for |Qc| is not equal to zero.

Step4: Determine Qo using formula

Qo = [CT ATCT (AT)2CT………. (AT)n-1CT]

Step5: Check for |Qo| is not equal to zero.

Step6: Find Rank for both Qc and Qo.

**Matlab code**

%% Check for observability and controllability

clear

close all

clc

%% Consider the system representation

A=[ 1 0;0 0 1;-6 -11 -6];

B=[0; 0; 2];

C=[1 0 0];

D=0;

% eigenvaues (just for checking stability)

E=eig(A);

%% Controllability Test

Qc1=[B A\*B A^2\*B];

det\_Qc1 = det(Qc1);

R1=rank(Qc1);

disp('Controllability Matrix');

disp(Qc1);

fprintf('Determinant Value %d\n',det\_Qc1);

fprintf('Rank %d\n',R1);

%% Observability Test

At = A';

Ct=C';

Qo1=[Ct, At\*Ct, (At)^2\*Ct];

R2=rank(Qo1);

det\_Qo1=det(Qo1);

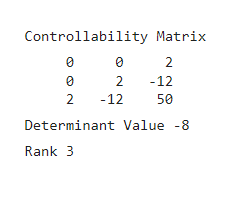
disp('Observability Matrix');

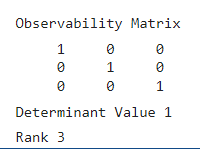
disp(Qo1);

fprintf('Determinant Value %d\n',det\_Qo1);

fprintf('Rank %d \n',R2);

**Output**

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**Inference**

**Result**

Thus, the Controllability and Observability test in simulation platform is performed and verified.