Programming Assignment 1

NAVI CONTROL SYSTEM

VERSION 1.0

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Overview

Project has been development using heavy object oriented methodology with minimum to almost no hard coded section. Main Execution is performed on two closely related objects; Accelerator and Display which are spawned from the same base class. Each of these objects are to run independently and concurrently.

Design

Accelerator Thread:

Single and main function run() who has but one task; calculate the velocity and distance of a moving object. At a given periodic time, a pulse is sent out to this unique object that initiates the calculation. Using simulated accelerated variables the objects performs calculation in order to populate the current velocity and distance. While performing this calculation, the objects restricts access to the shared Navy data variables to avoid having partial or incorrect data since each axis is related to one another through time.

This dependency forced us to lock completely the data structure while performing calculation. Though the thought of copying the data from shared memory location onto a temporary local variable, performing the calculation and storing the values back to the shared data structure was an option but would have generated must worst time execution for Display thread. In other words, if display thread would get access of the shared variables while the accelerator thread performs calculation would produce and output that is no up to date and the next refresh cycle would only occur in 6 seconds. Having to wait couple of extra cycles or micro seconds to get the accurate up to date variable made more sense than to have almost lockless synchronization.

Display Thread:

Much like the Accelerator object, this too has one main function run() that outputs the values of each coordinate for distance and velocity vector. The major difference in this thread object is quick execution time. For this reason, the display thread locks mutex only during the copying the values from the variables from shared data structure onto the local one. Then, the lock is released and the object outputs the values onto the screen. Though, at this moment, the difference in time might be unnoticed but having future design in mind of a possible TCP or other network protocol to translate the information will have a significant time constraint and should not be locking the data structure for that duration.

Pulse Timer:

This object is instantiated to perform a signal generated pulse that will tell its dependent object to execute its tasks. Since different task require different timing constraints, this pulse timer object receives the periodic timing request and its identification number. Every Pulse timer is associated to a single object for this project but it can have multiple dependent children. In our assignment, accelerator thread gets two seconds pulse while the display thread six seconds.

Navy Data:

This object is a container for two data structures; velocity and distance. Each structure holds the x,y and z coordinate. It is accessed using a public member function that returns a pointer for fast easy data

manipulation. The emphasis is speed since we do not want the accelerator thread to waste time copying information back and forth and possibly miss the even timer pulse, we decided to pass all variables by reference. The single time the values are copied from is only done by the display data object.

Taking Time measurements:

For debugging and analysis purposes, extra execution or calculation have been placed in the code that calculates the current system time or cpu cycles. For most accurate results, all time measurements have been calculated using neutrino's proprietary functions. System time has been produced right after the timer event signal has been sent. For the execution time, we took the time stamps at the beginning of the execution and another one right after. This is to insure that our calculation or display output does not exceed the time of the timer pulse.

Timing Measurements

Testing performed on a QNX RTOS Neutrino Virtual Machine. The duration was set to 60 seconds and the output of each executed test is shown the following section.

The complete output log can be found in folder */navy/testing/

Calculation of the DAP and DD Execution Time

```
Main thread started!
Initializing mutex ...
Initializing NaviData ...
Constructing BaseThread ...
Channel successfully created
Constructing DisplayThread ...
Constructing BaseThread ...
Channel successfully created
Constructing AcceleratorThread ...
Ax: 20.000000, Ay: 20.693147, Az 9.000000
Ax: 20.693147, Ay: 21.098612, Az 11.079442
Ax: 21.098612, Ay: 21.386294, Az 12.295837
Ax: 21.386294, Ay: 21.609438, Az 13.158883
Ax: 21.609438, Ay: 21.791759, Az 13.828314
Ax: 21.791759, Ay: 21.945910, Az 14.375278
Ax: 21.945910, Ay: 22.079442, Az 14.837730
Ax: 22.079442, Ay: 22.197225, Az 15.238325
Ax: 22.197225, Ay: 22.302585, Az 15.591674
Ax: 22.302585, Ay: 22.397895, Az 15.907755
Ax: 22.397895, Ay: 22.484907, Az 16.193686
Ax: 22.484907, Ay: 22.564949, Az 16.454720
Ax: 22.564949, Ay: 22.639057, Az 16.694848
Ax: 22.639057, Ay: 22.708050, Az 16.917172
Ax: 22.708050, Ay: 22.772589, Az 17.124151
Ax: 22.772589, Ay: 22.833213, Az 17.317766
Ax: 22.833213, Ay: 22.890372, Az 17.499640
Ax: 22.890372, Ay: 22.944439, Az 17.671115
Ax: 22.944439, Ay: 22.995732, Az 17.833317
Ax: 22.995732, Ay: 23.044522, Az 17.987197
Ax: 23.044522, Ay: 23.091042, Az 18.133567
Ax: 23.091042, Ay: 23.135494, Az 18.273127
Ax: 23.135494, Ay: 23.178054, Az 18.406483
Ax: 23.178054, Ay: 23.218876, Az 18.534161
Ax: 23.218876, Ay: 23.258097, Az 18.656627
Ax: 23.258097, Ay: 23.295837, Az 18.774290
Ax: 23.295837, Ay: 23.332205, Az 18.887511
Ax: 23.332205, Ay: 23.367296, Az 18.996614
Ax: 23.367296, Ay: 23.401197, Az 19.101887
Ax: 23.401197, Ay: 23.433987, Az 19.203592
Ax: 23.433987, Ay: 23.465736, Az 19.301962
Creating and initializing PulseTimer ...
Connection attached successfully
Timer created successfully
Creating and initializing PulseTimer ...
```

Connection attached successfully
Timer created successfully
----------Begin----------

Timer started
Timer started

Display pulse 1 received at time 1 seconds
Distance: x: 0.000000, y: 0.000000, z: 0.000000
Velocity: Vx: 0.000000, Vy: 0.000000, Vz: 0.000000
Display Execution time 0.000409 seconds

Accelerator pulse 1 received at time 1 seconds
Accelerator Execution time 0.000848 seconds

Accelerator pulse 2 received at time 3 seconds
Accelerator Execution time 0.000793 seconds

Accelerator pulse 3 received at time 5 seconds
Accelerator Execution time 0.000811 seconds

Display pulse 2 received at time 7 seconds
Distance: x: 489.939627, y: 502.651842, z: 10.618875
Velocity: Vx: 123.583519, Vy: 126.356108, Vz: 5.950556
Display Execution time 0.000310 seconds

Accelerator pulse 4 received at time 7 seconds
Accelerator Execution time 0.000816 seconds

Accelerator pulse 5 received at time 9 seconds
Accelerator Execution time 0.000778 seconds

Accelerator pulse 6 received at time 11 seconds
Accelerator Execution time 0.000798 seconds

Display pulse 3 received at time 13 seconds
Distance: x: 1748.118814, y: 1782.219459, z: 137.156425
Velocity: Vx: 253.158502, Vy: 257.050323, Vz: 29.875505
Display Execution time 0.000373 seconds

Accelerator pulse 7 received at time 13 seconds
Accelerator Execution time 0.000800 seconds

Accelerator pulse 8 received at time 15 seconds
Accelerator Execution time 0.000802 seconds

Accelerator pulse 9 received at time 17 seconds
Accelerator Execution time 0.000848 seconds

Display pulse 4 received at time 19 seconds
Distance: x: 3795.845181, y: 3856.262831, z: 443.535508
Velocity: Vx: 385.603655, Vy: 390.208825, Vz: 62.410961
Display Execution time 0.000351 seconds

Accelerator pulse 10 received at time 19 seconds

Accelerator Execution time 0.000805 seconds

Accelerator pulse 11 received at time 21 seconds
Accelerator Execution time 0.000818 seconds

Accelerator pulse 12 received at time 23 seconds
Accelerator Execution time 0.000803 seconds

Display pulse 5 received at time 25 seconds
Distance: x: 6646.220920, y: 6736.429576, z: 969.062702
Velocity: Vx: 519.974429, Vy: 525.104328, Vz: 100.723282
Display Execution time 0.000371 seconds

Accelerator pulse 13 received at time 25 seconds
Accelerator Execution time 0.000777 seconds

Accelerator pulse 14 received at time 27 seconds
Accelerator Execution time 0.000808 seconds

Accelerator pulse 15 received at time 29 seconds
Accelerator Execution time 0.000776 seconds

Display pulse 6 received at time 31 seconds
Distance: x: 10308.791546, y: 10431.478986, z: 1742.374547
Velocity: Vx: 655.798543, Vy: 661.343720, Vz: 143.395623
Display Execution time 0.000310 seconds

Accelerator pulse 16 received at time 31 seconds
Accelerator Execution time 0.000776 seconds

Accelerator pulse 17 received at time 33 seconds
Accelerator Execution time 0.000770 seconds

Accelerator pulse 18 received at time 35 seconds
Accelerator Execution time 0.000777 seconds

Display pulse 7 received at time 37 seconds
Distance: x: 14791.081061, y: 14948.440598, z: 2786.043053
Velocity: Vx: 792.790890, Vy: 798.679768, Vz: 189.572664
Display Execution time 0.000339 seconds

Accelerator pulse 19 received at time 37 seconds
Accelerator Execution time 0.000819 seconds

Accelerator pulse 20 received at time 39 seconds
Accelerator Execution time 0.000815 seconds

Accelerator pulse 21 received at time 41 seconds
Accelerator Execution time 0.000788 seconds

Display pulse 8 received at time 43 seconds
Distance: x: 20099.303619, y: 20293.188345, z: 4118.710682
Velocity: Vx: 930.760278, Vy: 936.942363, Vz: 238.680825
Display Execution time 0.000307 seconds

Accelerator pulse 22 received at time 43 seconds
Accelerator Execution time 0.000797 seconds

Accelerator pulse 23 received at time 45 seconds
Accelerator Execution time 0.000863 seconds

Accelerator pulse 24 received at time 47 seconds
Accelerator Execution time 0.000777 seconds

Display pulse 9 received at time 49 seconds
Distance: x: 26238.753965, y: 26470.768385, z: 5756.261665
Velocity: Vx: 1069.569459, Vy: 1076.007210, Vz: 290.308367
Display Execution time 0.000324 seconds

Accelerator pulse 25 received at time 49 seconds
Accelerator Execution time 0.000775 seconds

Accelerator pulse 26 received at time 51 seconds
Accelerator Execution time 0.000777 seconds

Accelerator pulse 27 received at time 53 seconds
Accelerator Execution time 0.000826 seconds

Display pulse 10 received at time 55 seconds
Distance: x: 33214.045347, y: 33485.604320, z: 7712.535753
Velocity: Vx: 1209.115077, Vy: 1215.779486, Vz: 344.145221
Display Execution time 0.000391 seconds

Accelerator pulse 28 received at time 55 seconds
Accelerator Execution time 0.000993 seconds

Accelerator pulse 29 received at time 57 seconds
Accelerator Execution time 0.000848 seconds

Accelerator pulse 30 received at time 59 seconds
Accelerator Execution time 0.000924 seconds

AcceleratorThread 3 done at 59 seconds

DAP Worst-case execution time: 0.000993
DAP Best-case execution time: 0.000770
DAp Average execution time: 0.000813

Display pulse 11 received at time 61 seconds
Distance: x: 41029.265421, y: 41341.634315, z: 9999.795908
Velocity: Vx: 1349.316473, Vy: 1356.184447, Vz: 399.949407
Display Execution time 0.000320 seconds

DisplayThread done 2

DD Worst-case execution time: 0.000409
DD Best-case execution time: 0.000307
DD Average execution time: 0.000346

----------END----------

Destroying PulseTimer ...
Destroying PulseTimer ...
Destroying DisplayThread ...
Destroying BaseThread ...
Destroying AcceleratorThread ...
Destroying BaseThread ...

Individual DAP Iteration Execution Time

Timer started

Accelerator pulse 1 received at time 1 seconds
Accelerator Execution time 0.000842 seconds

Accelerator pulse 2 received at time 3 seconds
Accelerator Execution time 0.000925 seconds

Accelerator pulse 3 received at time 5 seconds
Accelerator Execution time 0.000844 seconds

Accelerator pulse 4 received at time 7 seconds
Accelerator Execution time 0.000811 seconds

Accelerator pulse 5 received at time 9 seconds
Accelerator Execution time 0.000888 seconds

Accelerator pulse 6 received at time 11 seconds
Accelerator Execution time 0.000799 seconds

Accelerator pulse 7 received at time 13 seconds
Accelerator Execution time 0.000790 seconds

Accelerator pulse 8 received at time 15 seconds
Accelerator Execution time 0.000851 seconds

Accelerator pulse 9 received at time 17 seconds
Accelerator Execution time 0.000846 seconds

Accelerator pulse 10 received at time 19 seconds
Accelerator Execution time 0.000811 seconds

Accelerator pulse 11 received at time 21 seconds
Accelerator Execution time 0.000835 seconds

Accelerator pulse 12 received at time 23 seconds
Accelerator Execution time 0.000798 seconds

Accelerator pulse 13 received at time 25 seconds

Accelerator Execution time 0.000790 seconds

Accelerator pulse 14 received at time 27 seconds
Accelerator Execution time 0.000789 seconds

Accelerator pulse 15 received at time 29 seconds
Accelerator Execution time 0.000731 seconds

Accelerator pulse 16 received at time 31 seconds
Accelerator Execution time 0.000851 seconds

Accelerator pulse 17 received at time 33 seconds
Accelerator Execution time 0.000784 seconds

Accelerator pulse 18 received at time 35 seconds
Accelerator Execution time 0.000842 seconds

Accelerator pulse 19 received at time 37 seconds
Accelerator Execution time 0.000613 seconds

Accelerator pulse 20 received at time 39 seconds
Accelerator Execution time 0.000806 seconds

Accelerator pulse 21 received at time 41 seconds
Accelerator Execution time 0.000788 seconds

Accelerator pulse 22 received at time 43 seconds
Accelerator Execution time 0.000850 seconds

Accelerator pulse 23 received at time 45 seconds
Accelerator Execution time 0.000885 seconds

Accelerator pulse 24 received at time 47 seconds
Accelerator Execution time 0.000866 seconds

Accelerator pulse 25 received at time 49 seconds
Accelerator Execution time 0.000877 seconds

Accelerator pulse 26 received at time 51 seconds
Accelerator Execution time 0.000793 seconds

Accelerator pulse 27 received at time 53 seconds
Accelerator Execution time 0.000793 seconds

Accelerator pulse 28 received at time 55 seconds
Accelerator Execution time 0.000533 seconds

Accelerator pulse 29 received at time 57 seconds

Accelerator Execution time 0.000890 seconds

Accelerator pulse 30 received at time 59 seconds
Accelerator Execution time 0.000748 seconds

AcceleratorThread 2 done at 59 seconds

Individual DD Iteration Execution Time

Timer started

Display pulse 1 received at time 1 seconds
Distance: x: 0.000000, y: 0.000000, z: 0.000000
Velocity: Vx: 0.000000, Vy: 0.000000, Vz: 0.000000
Display Execution time 0.000348 seconds

Display pulse 2 received at time 7 seconds
Distance: x: 0.000000, y: 0.000000, z: 0.000000
Velocity: Vx: 0.000000, Vy: 0.000000, Vz: 0.000000
Display Execution time 0.000293 seconds

Display pulse 3 received at time 13 seconds
Distance: x: 0.000000, y: 0.000000, z: 0.000000
Velocity: Vx: 0.000000, Vy: 0.000000, Vz: 0.000000
Display Execution time 0.000345 seconds

Display pulse 4 received at time 19 seconds
Distance: x: 0.000000, y: 0.000000, z: 0.000000
Velocity: Vx: 0.000000, Vy: 0.000000, Vz: 0.000000
Display Execution time 0.000755 seconds

Display pulse 5 received at time 25 seconds
Distance: x: 0.000000, y: 0.000000, z: 0.000000
Velocity: Vx: 0.000000, Vy: 0.000000, Vz: 0.000000
Display Execution time 0.000547 seconds

Display pulse 6 received at time 31 seconds
Distance: x: 0.000000, y: 0.000000, z: 0.000000
Velocity: Vx: 0.000000, Vy: 0.000000, Vz: 0.000000
Display Execution time 0.000320 seconds

Display pulse 7 received at time 37 seconds
Distance: x: 0.000000, y: 0.000000, z: 0.000000
Velocity: Vx: 0.000000, Vy: 0.000000, Vz: 0.000000
Display Execution time 0.000341 seconds

Display pulse 8 received at time 43 seconds
Distance: x: 0.000000, y: 0.000000, z: 0.000000

Velocity: Vx: 0.000000, Vy: 0.000000, Vz: 0.000000
Display Execution time 0.000415 seconds

Display pulse 9 received at time 49 seconds
Distance: x: 0.000000, y: 0.000000, z: 0.000000
Velocity: Vx: 0.000000, Vy: 0.000000, Vz: 0.000000
Display Execution time 0.000312 seconds

Display pulse 10 received at time 55 seconds
Distance: x: 0.000000, y: 0.000000, z: 0.000000
Velocity: Vx: 0.000000, Vy: 0.000000, Vz: 0.000000
Display Execution time 0.000302 seconds

Display pulse 11 received at time 61 seconds
Distance: x: 0.000000, y: 0.000000, z: 0.000000
Velocity: Vx: 0.000000, Vy: 0.000000, Vz: 0.000000
Display Execution time 0.000340 seconds

Best Case and Worst Case Scenario

The following results are taken from both individual execution as well as the simulated current execution.

DAP

The Results for simulated concurrent execution:

DAP Worst-case execution time: 0.000993
DAP Best-case execution time: 0.000770
DAP Average execution time: 0.000813

The Results for stand-alone execution:

Worst-case execution time: 0.000925
Best-case execution time: 0.000533
Average execution time: 0.000809

BCET:
0.000533
WCET:
0.000993

DD

The Results for simulated concurrent execution:

Worst-case execution time: 0.001576
Best-case execution time: 0.000336
Average execution time: 0.000546

The Results for stand-alone execution:

Worst-case execution time: 0.000755

Best-case execution time: 0.000293
Average execution time: 0.000393

BCET:

0.000293

WCET:

0.001576