STU FEI
ÚSTAV ROBOTIKY A KYBERNETIKY

Kolekcia učebných textov

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RJ

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KUTdevAS1

Laboratórne zariadenie AeroShield: softváre Matlab

Cieľom textu je zoznámenie sa s obslužným Matlab softvárom pre prácu so zariadením *AS*, ktorý slúži na meranie a ovládanie spomínaného zariadenia.

1 Hlavný program

Výpis kódu 1: Zavolanie funkcie merania.

```
% ----------------------------------
% Run the experiment using the following line of code
% ----------------------------------

[t, y, u, potentiometer, yhat, dyhat] = runArduinoPlot();

% ----------------------------------
% ----------------------------------
```

Info.

2 Dátový priečinok

Výpis kódu 2: Vytvorenie dátového priečinku.

```
% ----------------------------------
% Create the data repository
% ----------------------------------
DDIR = "dataRepo";
if ~exist(DDIR, "dir")
    fprintf("Creating the data directory...");
    mkdir(DDIR);
end
% ----------------------------------
% ----------------------------------
```

Info.

3 Definícia premenných

Výpis kódu 3: Definícia všetkých potrebných premenných.

```
% ----------------------------------
% Define all the parameters
% ----------------------------------

```

```
% Define time parameters

T_start = 0;

T_sample = 3;       % [ms] <1, 255>

% Define STOP TIME

T_stop = 60.0;      % [sec]

% Define control parameters
U_MAX = 100.0;
U_MIN = 0.0;
Y_SAFETY = 190.0;

% Define PID param
P = 1.0;
I = 0.30;
D = 0.19;

R_WANTED = 140;

% alpha - beta filter
alpha = 0.8;
beta = 0.2;

timer_t = [];
timer_y = [];
timer_yhat = [];
timer_dyhat = [];
timer_u = [];
timer_potentiometer = [];
% ----------------------------------
% ----------------------------------
```

Info.

4 Vykreslenie dát v reálnom čase

Výpis kódu 4: Definícia časovača na vykreslenie meraných dát v reálnom čase.

```
% ----------------------------------
% Plot the measured data in real time
% ----------------------------------
function plotData()
    persistent hy hr hu;
    try
        if isempty(hy) || isempty(hr) || isempty(hu)
            f = figure(9999); clf(f);
            ax = axes(f);
            hold on;
            hy = plot(ax, nan, nan, '.b');
            hr = plot(ax, nan, nan, '.r');
            hu = plot(ax, nan, nan, '.k');
            grid minor;
            title("Real-Time System Response");
            xlabel("t [s]");
            ylabel("$\varphi [^\circ]$", "Interpreter","latex");
            legend(ax, "y","ref", "yhat", 'Location', 'southeast');

        end

        % plot(plot_t, plot_sig_3,'.b', plot_t, plot_sig_2,'.r', plot_t,
        % plot_sig_1,'.k')
        % print(timer_t(1));

        set(hy, 'YData', timer_y, 'XData', timer_t);
        set(hr, 'YData', timer_potentiometer, 'XData', timer_t);
        set(hu, 'YData', timer_yhat, 'XData', timer_t);
        drawnow limitrate nocallbacks;
    catch err
```

```
31          fprintf(2, "Plot thread: " + err.message + "\n");
32      end
33  end
34
35  tPlot = timer('ExecutionMode','fixedRate', 'Period', 0.5, 'TimerFcn', @
        (~, ~) plotData());
36  start(tPlot);
37  % ----------------------------------
38  % ----------------------------------
```

Info.

5 Záznamové súbory merania

Výpis kódu 5: Inicializácia záznamových súborov.

```
1   % ----------------------------------
2   % Initialize File Streams
3   % ----------------------------------
4
5   DateString = convertCharsToStrings(datestr(datetime('now'), "
        yyyy_mm_dd_HH_MM_ss"));
6
7   FILENAME = "dataFile";
8
9   function fullpath = getfilename(dirpath, filename, datestr, ext)
10      if nargin < 3
11          error("At least the first 3 parameters need to be provided.");
12      end
13      if nargin == 3
14          ext = "csv";
15      end
16
17      fullpath = "./" + dirpath + "/" + filename + "_" + datestr + "." +
            ext;
18  end
19
20  FILEPATH = getfilename(DDIR, FILENAME, DateString);
21  FILEPATH_MAT = getfilename(DDIR, FILENAME, DateString, 'mat');
22
23  if(exist("datafileID", "var"))
24      fclose(datafileID);
25      clear datafileID;
26  end
27
28  datafileID = fopen(FILEPATH,'w');
29  fprintf(datafileID, 't, tp, r, y, u, dtp, dt\n');
30  % ----------------------------------
31  % ----------------------------------
```

Info.

6 Zapisovanie dát merania

Výpis kódu 6: Zapisovanie meraných dát do súboru a konzoly.

```
1   % ----------------------------------
2   % Write data into files
3   % ----------------------------------
4
5   function updateInfo(datafileID, dt, Ts, x)
6       if ((dt) > (Ts*1.05))
7           fprintf('%8.3f %8.3f %8.3f %8.3f %8.3f %8.3f %8.3f  --\n', x);
8       else
9           fprintf('%8.3f %8.3f %8.3f %8.3f %8.3f %8.3f %8.3f\n', x);
10      end
11      fprintf(datafileID, '%8.3f, %8.3f, %8.3f, %8.3f, %8.3f, %8.3f, %8.3f
            \n', x);
```

```
12      timer_t = [timer_t x(1)];
13      timer_y = [timer_y x(4)];
14      timer_u = [timer_u x(5)];
15      timer_potentiometer = [timer_potentiometer x(3)];
16  end
17
18  doUpdate = @(x) updateInfo(datafileID, x(end), T_sample, x);
19
20  % ---------------------------------
21  % ---------------------------------
```

Info.

7 Sériová komunikácia

Výpis kódu 7: Inicializácia sériovej komunikácie a konfigurácia.

```
1   % ---------------------------------
2   % Define serial port parameters, open and configure comms
3   % ---------------------------------
4
5   if(exist("serPort", "var"))
6       serPort.flush("input");
7       clear serPort;
8   end
9
10  serPort = serialport('COM3', 115200, 'Timeout', 5);
11
12  serLine = readline(serPort);
13
14  while(~contains(serLine, "config"))
15      disp(serLine);
16      serLine = readline(serPort);
17  end
18
19  fprintf("Sending now\n");
20  write(serPort, cast(T_sample, "uint8"), "uint8");
21
22  % Read the first line from the serial port (MCU starting)
23  while(~contains(serLine, "start"))
24      disp(serLine);
25      serLine = readline(serPort);
26  end
27
28  disp(serLine);
29  write(serPort, 0.0, 'single'); % Necessary to send this command for
        stable sampling period
30
31  while(contains(serLine, "---"))
32      disp(serLine);
33      serLine = readline(serPort);
34  end
35
36  % Read and parse the calibration data
37  serLineList = str2num(serLine); %#ok<ST2NM>
38
39  % ---------------------------------
40  % ---------------------------------
```

Info.

8 Počiatočné hodnoty

Výpis kódu 8: Zaznamenanie počiatočných hodnôt.

```
1   % ---------------------------------
2   % Extract the initial values from the received data
3   % ---------------------------------
```

```
plant_time_init = serLineList(1);
plant_potentiometer_init = serLineList(2);
plant_output_init = serLineList(3);
plant_input_init = serLineList(4);

plant_time = serLineList(1) - plant_time_init;
plant_input = serLineList(2);
plant_output = serLineList(3);
plant_potentiometer = R_WANTED + serLineList(4)/100*20;
plant_dt = serLineList(5);

timer_yhat = [timer_yhat, plant_output];
timer_dyhat = [timer_dyhat, 0];

% Display the received data
tmp_printlist = [0, plant_time, plant_potentiometer, plant_output,
    plant_input, plant_dt, T_sample];
doUpdate(tmp_printlist);
% ---------------------------------
% ---------------------------------
```

Info.

9 Definícia premenných hlavne slučky

Výpis kódu 9: Nastavenie premenných v hlavnej slučke.

```
% ---------------------------------
% Set the main loop parameters
% ---------------------------------

% Set initial control input value
e_old = 0;
e_int_old = 0;
u = 0;
u_send = u;


% Get the initial time
time_start = datetime('now');
time_tick = time_start;

% ---------------------------------
% ---------------------------------
```

Info.

10 Čítanie sériovej komunikácie

Výpis kódu 10: Definícia počúvateľa sériovej komunikácie.

```
% ---------------------------------
% Define serial link listener
% ---------------------------------

function readSerialData(src, ~)
    data = readline(src);
    src.UserData = data;
end

configureCallback(serPort, "terminator", @readSerialData);
% ---------------------------------
```

Info.

11 Spracovanie sériovej komunikácie

Výpis kódu 11: Spracovanie a zaznamenie dát zo sériovej komunikácie.

```
% ----------------------------------
% Process the read data from the serial communication
% ----------------------------------
waitfor(serPort, "UserData");

% Get current time
time_curr = datetime('now');

% Calculate time elapsed since last iteration
time_delta = milliseconds(time_curr - time_tick);

% Read and parse the received data
serLineList = str2num(serPort.UserData); %#ok<ST2NM>

time_tick = time_curr;

% Calculate total time elapsed
time_elapsed = seconds(time_curr - time_start);

% Extract values from the received data
plant_time = serLineList(1) - plant_time_init;
plant_input = serLineList(2);
plant_output = serLineList(3);
plant_potentiometer = R_WANTED + serLineList(4)/100*20;
plant_dt = serLineList(5);

dx = plant_output - timer_yhat(end);
cyhat = timer_yhat(end) + alpha*(dx);
timer_yhat = [timer_yhat, cyhat];
timer_dyhat = [timer_dyhat, timer_dyhat(end) + beta*(dx/time_delta)];

% Record the received data
tmp_printlist = [time_elapsed, plant_time, plant_potentiometer,
    plant_output, plant_input, plant_dt, time_delta];
doUpdate(tmp_printlist);

% ----------------------------------
% ----------------------------------
```

Info.

12 Vlastný program

Výpis kódu 12: Blok pre vlastný program

```
% ----------------------------------
% Insert your code here (for example, we have PID controller code
    implemented in this space)
% ----------------------------------

e = plant_potentiometer - plant_output;

e_der = (e - e_old) / (time_delta/1000);

e_int = e_int_old + (e * (time_delta/1000));

e_old = e;
e_int_old = e_int;


u = P * e  +  I * e_int + D * e_der;
```

Info.

13 Saturácia akčného zásahu

Výpis kódu 13: Obmedzenie akčného zásahu na maximálne a minimálne hodnoty.

```
% ----------------------------------
% Saturate the control output to the MAX and MIN values
% ----------------------------------

u_send = u;

if u_send > U_MAX
    u_send = U_MAX;
elseif u_send < U_MIN
    u_send = U_MIN;
end

% ----------------------------------
% ----------------------------------
```

Info.

14 Posielanie sériovej komunikácie

Výpis kódu 14: Funkcia na posielanie žiadanej akčnej veličiny po sériovej linke.

```
% ----------------------------------
% Send control input to the serial port
% ----------------------------------

write(serPort, u_send, "single");

% ----------------------------------
% ----------------------------------
```

Info.

15 Konečná podmienka merania

Výpis kódu 15: Podmienka na bezpečné ukončenie merania.

```
% ----------------------------------
% Check if the simulation should stop (safety precaution)
% ----------------------------------

if time_elapsed >= T_stop || plant_output >= Y_SAFETY
    configureCallback(serPort, "off"); % Remove the callback from the
        serial port, before exiting the loop
    break;
end

% ----------------------------------
% ----------------------------------
```

Info.

16 Ukončenie časovačov

Výpis kódu 16: Ukončenie a odstránenie všetkých aktívnych Matlab časovačov.

```
% ----------------------------------
% Close and delete all the existing timers
% ----------------------------------

for tim=timerfindall
    stop(tim);
    delete(tim);
```

```
end

% ----------------------------------
% ----------------------------------
```

Info.

17 Ukončenie komunikácie

Výpis kódu 17: Ukončenie sériovej a súborovej komunikácie

```
% ----------------------------------
% Close the serial connection
% ----------------------------------

% Send a final command and close the serial port
write(serPort, 0.0, 'single');
serPort.flush("input");
clear serPort;
fclose(datafileID);
clear datafileID;

% ----------------------------------
% ----------------------------------
```

Info.

18 Uloženie merania

Výpis kódu 18: Ukladanie meracích dát do csv a mat súborov.

```
% ----------------------------------
% Save the measurement into a .MAT file for easier access to data when
    using Matlab
% ----------------------------------

logsout = readtable(FILEPATH, "VariableNamingRule","preserve","Delimiter
    ",",");

save(FILEPATH_MAT);

% ----------------------------------
% ----------------------------------
```

Info.

19 Vykreslenie priebehu merania

Výpis kódu 19: Vykreslenie základných veličín procesu merania.

```
% ----------------------------------
% Quickly plot the measurement - reference, output, and control signal
% ----------------------------------

t = logsout.t;
y = logsout.y;
u = logsout.u;
r = logsout.r;
e = r - y;
dt = logsout.dtp;


figure(111);
hold on;
plot(t, y, '-k', 'LineWidth', 1.5);
```

```
16 plot(t, r, '-r', 'LineWidth', 1.5);
17 plot(t, u, '-b', 'LineWidth', 1.5);
18 title('Control Response');
19 subtitle("P = " + num2str(P) + ", I = " + num2str(I) + ", D = " +
       num2str(D));
20 legend('y(t)', 'ref(t)', 'u(t)', "Location", "best");
21 xlabel('t [s]');
22 ylabel('y [deg]');
23 grid on;
24 hold off;
25 % ---------------------------------
26 % ---------------------------------
```

Info.

20 Vykreslenie priebehu $\alpha - \beta$ filtru

Výpis kódu 20: Vykreslenie priebehu a porovnania odhadu stavu pomocou $\alpha - \beta$ filtra.

```
1  % ---------------------------------
2  %% Plot the data
3  % ---------------------------------
4
5  figure(100);
6  subplot(3, 1, 1);
7  plot(t, y, t, yhat, t, potentiometer, 'LineWidth', 1.5);
8  grid minor;
9  legend('y','yhat','ref');
10 xlabel('t [s]');
11 ylabel('$\varphi [^\circ]$', 'Interpreter', 'latex');
12 title('System response');
13 subtitle("$\alpha - \beta$ filter", 'Interpreter', 'latex');
14
15 subplot(3, 1, 2);
16 plot(t, dyhat, 'LineWidth', 1.5);
17 grid minor;
18 xlabel('t [s]');
19 ylabel('$\omega [^\circ/s]$', 'Interpreter', 'latex');
20 title('System velocity response');
21 subtitle("$\alpha - \beta$ filter", 'Interpreter', 'latex');
22
23 subplot(3, 1, 3);
24 plot(t, (y-yhat), 'LineWidth', 1.5);
25 grid minor;
26 xlabel('t [s]');
27 ylabel('$\varphi [^\circ]$', 'Interpreter', 'latex');
28 title('Observer error');
29 subtitle("$\alpha - \beta$ filter", 'Interpreter', 'latex');
30
31 % ---------------------------------
32 % ---------------------------------
```

Info.