Laboratory 6 - Approximation

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You are the team member, taking part in a project aiming to create a system to measure a strength of wireless signals (Wi-Fi, Zig-Bee, LTE, 5G etc.) inside buildings. The system consists of:

- a drone equipped with appropriate sensors,
- drone location system (3 antennas, the location of the drone is determined by measuring the signal strength from each of the antennas),
- server collecting measurement data. Based on the computed trajectory of the drone, a 3D distribution map of a signal strength is created inside the test room.

The location of the drone is determined at regular intervals based on the location system, however, the error of location system is approx. 5%. Load file *trajektoria1.mat* and plot the location of the drone using *plot3(x, y, z, 'o'), grid on, axis equal.* Vector n with M elements contains the moments of time in which the drone position was determined.

1 Task 1

Your first task is to determine the function which approximates the drone position. Is it better to use interpolation or approximation? Write down the answer in *Index_name_task1.txt* file.

2 Task 2

Use the function $[coeff,\ x_{approx}] = ApproximationPoly(n, x, N)$ to approximate the position of the drone using polynomials for $N = 50$ (order of approximation). Approximation function for x has the form:

$$x_{approx} = c_0 + c_1 n + c_2 n^2 + \cdots + c_N n^N \tag{1}$$

Note - you need to approximate the *x, y, z* coordinates separately. Plot in one window trajectory of the drone based on location (graph: 'o') and approximated (graph:'LineWidth', 4). Save the plot in a file named *Index_name_task2.png*

3 Task 3

The team member responsible for the system tests noticed that for the trajectory with a fewer measurement nodes (larger time intervals), the algorithm generates huge errors. Your next task is to find the error and correct the algorithm. Plot the location of the drone (real location and approximation) for data from *trajectory2.mat* and $N = 50$. Note that the location of the drone is determined at larger intervals. Save the plot to a file named *Index_name_task3.png*

4 Task 4

What is the name of the effect which causes the above error? Create an error plot for $N = 1, 2 \ldots 71$ and save it: *Index_name_task4.png*, where:

$$err = err_x + err_y + err_z \tag{2}$$

where:

$$err_x = \frac{\sqrt{\sum_i^N (x_{approx}(i) - x(i))^2}}{M} \tag{3}$$

and similarly for y and z.

5 Task 5

Apply an approximation using trigonometric functions. To this end use:

- basis functions: $cos(n), cos(2n), \ldots cos(Nn)$
- the approximation function has the form:

$$x_{approx} = c_1 cos(n) + c_2 cos(2n) + \cdots + c_N cos(Nn) \tag{4}$$

- the coefficients c_i are obtained from the system of equations:

$$\mathbf{Sc} = \mathbf{t} \tag{5}$$

- where:

$$t_k = \sum_{i=1}^{M} (cos(kn_i) x_i) \tag{6}$$

$$S_{kl} = \sum_{i=1}^{M} (cos(kn_i) cos(ln_i)) \tag{7}$$

The formula for $\mathbf{t}$ vector is already implemented in *approx_tryg.m* function. Implement the code, which will generate the $\mathbf{S}$ matrix and will solve the system (5). Save the proper plots in *Index_name_task5.png*

6 Task 6

The last task is to check if the trigonometric approximation is prone to the Runge effect.

- Create appropriate plot and save it in the file.
- N value can be automatically determined (based on the error graph). Implement the appropriate solution.