**code:**

% CS5486 Intelligent Systems Assignment 2 - Complete Implementation

clear; clc; close all;

%% 1. Generate training samples and test samples

N = 100;

x = -5 + (5+5)\*rand(N, 2); % Uniform distribution in [-5,5]^2

z = sin(x(:,1) + x(:,2));

% Generate test samples

test = -5 + (5+5)\*rand(N, 2);

testtarget = sin(test(:,1) + test(:,2));

% Generate test samples on regular grid for visualization

[x1\_grid, x2\_grid] = meshgrid(-5:0.2:5, -5:0.2:5);

x\_grid = [x1\_grid(:), x2\_grid(:)];

% Display training samples

disp('Training samples (x1, x2, z):');

disp(table(x(:,1), x(:,2), z, 'VariableNames', {'x1', 'x2', 'z'}));

%% 2. Training and evaluation using standard SVR (Support Vector Regression)

tic;

model\_svr = fitrsvm(x, z, 'KernelFunction', 'gaussian', 'KernelScale', 1);

svr\_time = toc;

z\_pred\_svr = predict(model\_svr, test);

svr\_mse = mean((sin(test(:,1) + test(:,2)) - z\_pred\_svr).^2);

% Output SVR details

fprintf('\n--- SVR Details ---\n');

fprintf('SVR Mean Squared Error: %.5f\n', svr\_mse);

fprintf('SVR Training Time: %.5f seconds\n', svr\_time);

fprintf('Individual sample errors (SVR):\n');

for i = 1:N

fprintf('Sample %d error squared: %.6f\n', i, (testtarget(i)-z\_pred\_svr(i))^2);

end

%% 2D Grid Prediction for Visualization (SVR)

z\_pred\_svr\_grid = predict(model\_svr, x\_grid);

%% 2. Training and evaluation using LSSVM

type = 'f';

model\_lssvm = initlssvm(x, z, type, [], [], 'RBF\_kernel');

model\_lssvm = tunelssvm(model\_lssvm, 'simplex', 'crossvalidatelssvm', {10, 'mse'});

tic;

model\_lssvm = trainlssvm(model\_lssvm);

lssvm\_time = toc;

[z\_pred\_lssvm, ~] = simlssvm(model\_lssvm, test);

lssvm\_mse = mean((testtarget - z\_pred\_lssvm).^2);

% Output LSSVM details

fprintf('\n--- LSSVM Details ---\n');

disp('LSSVM Optimized Parameters:');

fprintf('Gamma = %.6f, Sigma^2 = %.6f\n', model\_lssvm.gam, model\_lssvm.kernel\_pars);

fprintf('LSSVM Mean Squared Error: %.5f\n', lssvm\_mse);

fprintf('LSSVM Training Time: ');

tic;

model\_lssvm = trainlssvm(model\_lssvm);

lssvm\_time = toc;

fprintf('%.5f seconds\n', lssvm\_time);

fprintf('Individual sample squared errors (LSSVM):\n');

for i = 1:N

sample\_error\_lssvm(i) = (testtarget(i)-z\_pred\_lssvm(i))^2;

fprintf('Sample %d squared error: %.8f\n', i, sample\_error\_lssvm(i));

end

%% 2D Grid Prediction for Visualization (LSSVM)

z\_pred\_lssvm\_grid = simlssvm(model\_lssvm, x\_grid);

%% 3. Visualization (3 plots)

% True function

figure;

surf(x1\_grid, x2\_grid, sin(x1\_grid + x2\_grid));

title('Ground Truth: sin(x + y)');

xlabel('x'); ylabel('y'); zlabel('z');

grid on;

% SVR Prediction

figure;

surf(x1\_grid, x2\_grid, reshape(z\_pred\_svr\_grid, size(x1\_grid)));

hold on; scatter3(x(:,1), x(:,2), z, 'filled', 'r');

title('SVR Prediction');

xlabel('x'); ylabel('y'); zlabel('z');

grid on;

% LSSVM Prediction

figure;

surf(x1\_grid, x2\_grid, reshape(z\_pred\_lssvm\_grid, size(x1\_grid)));

hold on; scatter3(x(:,1), x(:,2), z, 'filled', 'r');

title('LSSVM Prediction');

xlabel('x'); ylabel('y'); zlabel('z');

grid on;

%% 4. Final Comparison of Performance

fprintf('\nFinal Comparison Results:\n');

fprintf('--------------------------------------------\n');

fprintf('Method\t\tMSE\t\t\tTime(s)\n');

fprintf('SVR\t\t%.5f\t\t%.5f\n', svr\_mse, svr\_time);

fprintf('LSSVM\t\t%.5f\t\t%.5f\n', lssvm\_mse, lssvm\_time);

fprintf('--------------------------------------------\n');

**output in terminal:**

Training samples (x1, x2, z):

x1 x2 z

\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_

1.9247 -2.0456 -0.12055

-0.51313 -4.9851 0.70683

-0.93035 -4.4218 0.80226

-1.4315 -3.5852 0.95406

-3.2277 1.7441 -0.99619

3.5956 -2.3525 0.94679

-1.9451 -2.5587 0.97833

-4.0391 2.3969 -0.99745

2.2355 1.9077 -0.84233

2.3372 -0.62793 0.99042

4.4167 0.89873 -0.82363

2.382 0.50452 0.25227

2.2912 3.5968 -0.38498

-4.1832 4.0975 -0.085594

-1.961 -4.4943 -0.17122

-1.1506 -4.6799 0.43742

3.4889 -4.3408 -0.75256

1.285 1.6609 0.19449

-1.3201 -1.5757 -0.24329

-1.5347 -3.6952 0.86907

-4.2161 0.4656 0.57196

-3.4934 -2.9972 -0.20588

3.968 -2.7444 0.94033

1.2697 4.7894 -0.22224

0.70945 -4.3621 0.48906

-3.5271 -4.1358 -0.9818

-2.4145 0.1304 -0.75618

-4.6236 -2.8362 -0.92333

-0.38625 3.6037 -0.075766

0.63847 1.1527 0.97581

-2.8121 -1.6695 0.97349

-4.951 0.30757 0.99762

4.6466 -0.08578 -0.98853

3.791 1.8452 -0.60279

4.5553 2.5309 0.71943

-4.5125 4.6748 0.16161

0.95035 2.2259 -0.034655

4.5706 -1.1172 -0.30678

-2.2434 -1.5613 0.61557

-4.3619 -4.2484 -0.72737

1.4639 3.0975 -0.98863

-2.3508 -0.83497 0.044132

-0.87692 -4.2512 0.91483

1.317 -3.5518 -0.78757

-4.2771 -0.6411 0.9789

-1.6447 2.9862 0.97382

0.78964 4.6287 -0.761

-1.4635 4.895 -0.28592

-4.0645 -1.0783 0.90881

2.6446 -0.61449 0.89633

3.1314 -4.7357 -0.99944

4.2554 0.46481 -0.99997

-2.7784 -4.5665 -0.87319

-0.94045 -3.3813 0.92466

2.0198 -4.361 -0.71762

-3.8792 3.4314 -0.43302

-2.9476 2.7939 -0.15308

4.7595 0.064611 -0.99377

-1.3577 -4.1765 0.68096

-0.64826 -4.2303 0.98623

3.8892 -0.047107 -0.64458

-0.16736 -2.7131 -0.25815

0.79245 0.85042 0.9974

-4.6831 2.084 -0.51633

0.69869 -1.7153 -0.85032

4.9737 1.785 0.45778

2.3953 -4.7129 -0.73387

-1.766 3.4911 0.98812

3.247 -0.53044 0.41234

-3.9988 4.3837 0.37543

-2.7037 0.86961 -0.96553

-3.3073 -1.3045 0.99495

3.4854 -2.7324 0.68378

-1.1425 -4.3703 0.6964

2.9698 -4.6139 -0.99732

-1.5089 0.60759 -0.78411

2.1972 4.2063 0.12004

3.3634 3.9708 0.86794

-2.3914 -0.016052 -0.66998

-0.21731 -3.5518 0.58717

-4.3579 -0.45264 0.99519

-3.4232 4.2 0.70097

-1.8269 -3.6157 0.74504

4.7041 2.4121 0.73996

-2.7301 -2.7941 0.68819

-0.26435 -0.54851 -0.72626

-0.66677 0.76254 0.095626

-2.215 -0.58457 -0.3354

-2.0894 1.3211 -0.69496

-0.28969 -2.9019 0.049958

-1.8735 -2.5967 0.97081

2.8059 4.456 0.82979

4.4169 3.3795 0.99834

-3.5965 2.8228 -0.69877

3.5313 -2.1856 0.97477

-3.6377 -0.29124 0.70848

3.8973 -0.89448 0.13833

3.4659 1.8036 -0.84877

1.0486 2.0461 0.046794

4.4374 -0.57831 -0.6575

--- SVR Details ---

SVR Mean Squared Error: 0.06192

SVR Training Time: 0.00481 seconds

Individual sample errors (SVR):

Sample 1 error squared: 0.062473

Sample 2 error squared: 0.015807

Sample 3 error squared: 0.202557

Sample 4 error squared: 0.011453

Sample 5 error squared: 0.057078

Sample 6 error squared: 0.009827

Sample 7 error squared: 0.006425

Sample 8 error squared: 0.023923

Sample 9 error squared: 0.001809

Sample 10 error squared: 0.008136

Sample 11 error squared: 0.010797

Sample 12 error squared: 0.115314

Sample 13 error squared: 0.006489

Sample 14 error squared: 0.090629

Sample 15 error squared: 0.011859

Sample 16 error squared: 0.020131

Sample 17 error squared: 0.013394

Sample 18 error squared: 0.008594

Sample 19 error squared: 0.193838

Sample 20 error squared: 0.267733

Sample 21 error squared: 0.023157

Sample 22 error squared: 0.071192

Sample 23 error squared: 0.002813

Sample 24 error squared: 0.000682

Sample 25 error squared: 0.266673

Sample 26 error squared: 0.000099

Sample 27 error squared: 0.026164

Sample 28 error squared: 0.014787

Sample 29 error squared: 0.002259

Sample 30 error squared: 0.100006

Sample 31 error squared: 0.120792

Sample 32 error squared: 0.000883

Sample 33 error squared: 0.058459

Sample 34 error squared: 0.295265

Sample 35 error squared: 0.011895

Sample 36 error squared: 0.008222

Sample 37 error squared: 0.012992

Sample 38 error squared: 0.113737

Sample 39 error squared: 0.000688

Sample 40 error squared: 0.002445

Sample 41 error squared: 0.006984

Sample 42 error squared: 0.004978

Sample 43 error squared: 0.000098

Sample 44 error squared: 0.000508

Sample 45 error squared: 0.059260

Sample 46 error squared: 0.096011

Sample 47 error squared: 0.004337

Sample 48 error squared: 0.086754

Sample 49 error squared: 0.017384

Sample 50 error squared: 0.014604

Sample 51 error squared: 0.069034

Sample 52 error squared: 0.036096

Sample 53 error squared: 0.018507

Sample 54 error squared: 0.337031

Sample 55 error squared: 0.070468

Sample 56 error squared: 0.000689

Sample 57 error squared: 0.053612

Sample 58 error squared: 0.018287

Sample 59 error squared: 0.013876

Sample 60 error squared: 0.017446

Sample 61 error squared: 0.015675

Sample 62 error squared: 0.023168

Sample 63 error squared: 0.074997

Sample 64 error squared: 0.060456

Sample 65 error squared: 0.176843

Sample 66 error squared: 0.039115

Sample 67 error squared: 0.228724

Sample 68 error squared: 0.373779

Sample 69 error squared: 0.018305

Sample 70 error squared: 0.009214

Sample 71 error squared: 0.030248

Sample 72 error squared: 0.000020

Sample 73 error squared: 0.054433

Sample 74 error squared: 0.130711

Sample 75 error squared: 0.001883

Sample 76 error squared: 0.114189

Sample 77 error squared: 0.191619

Sample 78 error squared: 0.039601

Sample 79 error squared: 0.001460

Sample 80 error squared: 0.001177

Sample 81 error squared: 0.040643

Sample 82 error squared: 0.087069

Sample 83 error squared: 0.006032

Sample 84 error squared: 0.021113

Sample 85 error squared: 0.134709

Sample 86 error squared: 0.062970

Sample 87 error squared: 0.072961

Sample 88 error squared: 0.188249

Sample 89 error squared: 0.193520

Sample 90 error squared: 0.002907

Sample 91 error squared: 0.029719

Sample 92 error squared: 0.104424

Sample 93 error squared: 0.042725

Sample 94 error squared: 0.003765

Sample 95 error squared: 0.008863

Sample 96 error squared: 0.154375

Sample 97 error squared: 0.012054

Sample 98 error squared: 0.031525

Sample 99 error squared: 0.000213

Sample 100 error squared: 0.210833

Determine initial tuning parameters for simplex...: # cooling cycle(s) 1

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1. Coupled Simulated Annealing results: [gam] 17249.197

[sig2] 0.58175

F(X)= 0.002258

TUNELSSVM: chosen specifications:

2. optimization routine: simplex

cost function: crossvalidatelssvm

kernel function RBF\_kernel

3. starting values: 17249.197 0.581749847

Iteration Func-count min f(x) log(gamma) log(sig2) Procedure

1 3 1.335924e-03 10.9555 -0.5417 initial

2 5 1.335924e-03 10.9555 -0.5417 contract outside

3 9 1.318748e-03 10.8055 -0.8417 shrink

4 11 1.207631e-03 11.4055 -0.8417 reflect

5 15 1.017120e-03 11.1805 -0.6917 shrink

6 17 9.382422e-04 11.6680 -0.6167 expand

7 19 9.382422e-04 11.6680 -0.6167 contract inside

8 21 9.382422e-04 11.6680 -0.6167 contract outside

9 23 8.457974e-04 12.2704 -0.5933 expand

10 24 8.457974e-04 12.2704 -0.5933 reflect

11 25 8.457974e-04 12.2704 -0.5933 reflect

12 27 7.375461e-04 13.0497 -0.6003 expand

optimisation terminated sucessfully (MaxFunEvals criterion)

Simplex results:

X=464939.000203 0.548642, F(X)=7.375461e-04

Obtained hyper-parameters: [gamma sig2]: 464939.0002 0.5486423595

--- LSSVM Details ---

LSSVM Optimized Parameters:

Gamma = 464939.000203, Sigma^2 = 0.548642

LSSVM Mean Squared Error: 0.00007

LSSVM Training Time: 0.00093 seconds

Individual sample squared errors (LSSVM):

Sample 1 squared error: 0.00211330

Sample 2 squared error: 0.00000017

Sample 3 squared error: 0.00001636

Sample 4 squared error: 0.00000064

Sample 5 squared error: 0.00000205

Sample 6 squared error: 0.00000002

Sample 7 squared error: 0.00000007

Sample 8 squared error: 0.00003068

Sample 9 squared error: 0.00000279

Sample 10 squared error: 0.00003764

Sample 11 squared error: 0.00000033

Sample 12 squared error: 0.00000102

Sample 13 squared error: 0.00000226

Sample 14 squared error: 0.00009145

Sample 15 squared error: 0.00000003

Sample 16 squared error: 0.00000295

Sample 17 squared error: 0.00000033

Sample 18 squared error: 0.00000000

Sample 19 squared error: 0.00032706

Sample 20 squared error: 0.00000815

Sample 21 squared error: 0.00000023

Sample 22 squared error: 0.00002782

Sample 23 squared error: 0.00000136

Sample 24 squared error: 0.00000325

Sample 25 squared error: 0.00044117

Sample 26 squared error: 0.00000041

Sample 27 squared error: 0.00000002

Sample 28 squared error: 0.00000203

Sample 29 squared error: 0.00000744

Sample 30 squared error: 0.00002162

Sample 31 squared error: 0.00000000

Sample 32 squared error: 0.00000075

Sample 33 squared error: 0.00016768

Sample 34 squared error: 0.00200287

Sample 35 squared error: 0.00000115

Sample 36 squared error: 0.00000170

Sample 37 squared error: 0.00000161

Sample 38 squared error: 0.00000803

Sample 39 squared error: 0.00000080

Sample 40 squared error: 0.00000474

Sample 41 squared error: 0.00000176

Sample 42 squared error: 0.00000626

Sample 43 squared error: 0.00000000

Sample 44 squared error: 0.00000209

Sample 45 squared error: 0.00028226

Sample 46 squared error: 0.00000077

Sample 47 squared error: 0.00000440

Sample 48 squared error: 0.00000352

Sample 49 squared error: 0.00000000

Sample 50 squared error: 0.00000096

Sample 51 squared error: 0.00020910

Sample 52 squared error: 0.00000478

Sample 53 squared error: 0.00000027

Sample 54 squared error: 0.00001050

Sample 55 squared error: 0.00000084

Sample 56 squared error: 0.00003325

Sample 57 squared error: 0.00000781

Sample 58 squared error: 0.00004659

Sample 59 squared error: 0.00000028

Sample 60 squared error: 0.00000010

Sample 61 squared error: 0.00000342

Sample 62 squared error: 0.00000089

Sample 63 squared error: 0.00016163

Sample 64 squared error: 0.00007120

Sample 65 squared error: 0.00000152

Sample 66 squared error: 0.00001048

Sample 67 squared error: 0.00000151

Sample 68 squared error: 0.00054082

Sample 69 squared error: 0.00000086

Sample 70 squared error: 0.00000086

Sample 71 squared error: 0.00000542

Sample 72 squared error: 0.00000006

Sample 73 squared error: 0.00000306

Sample 74 squared error: 0.00000016

Sample 75 squared error: 0.00000295

Sample 76 squared error: 0.00002628

Sample 77 squared error: 0.00000004

Sample 78 squared error: 0.00000215

Sample 79 squared error: 0.00000129

Sample 80 squared error: 0.00019974

Sample 81 squared error: 0.00000000

Sample 82 squared error: 0.00000005

Sample 83 squared error: 0.00000005

Sample 84 squared error: 0.00000117

Sample 85 squared error: 0.00000040

Sample 86 squared error: 0.00000526

Sample 87 squared error: 0.00000240

Sample 88 squared error: 0.00000006

Sample 89 squared error: 0.00000263

Sample 90 squared error: 0.00000037

Sample 91 squared error: 0.00000185

Sample 92 squared error: 0.00000044

Sample 93 squared error: 0.00000057

Sample 94 squared error: 0.00000016

Sample 95 squared error: 0.00011576

Sample 96 squared error: 0.00000032

Sample 97 squared error: 0.00025521

Sample 98 squared error: 0.00000034

Sample 99 squared error: 0.00000107

Sample 100 squared error: 0.00009862

Final Comparison Results:

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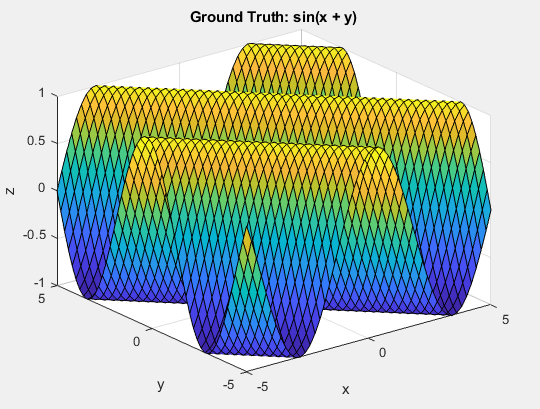
Method MSE Time(s)

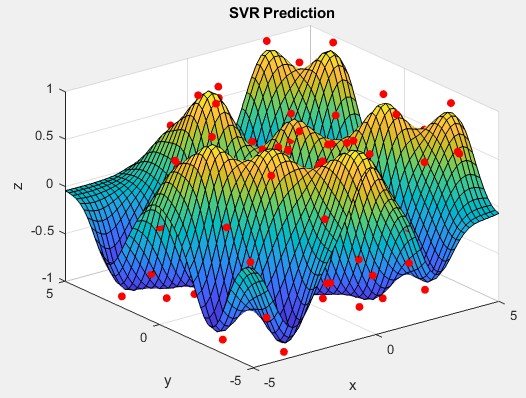
SVR 0.06192 0.00481

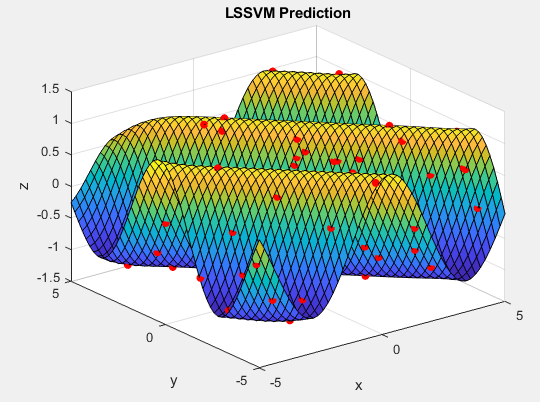
LSSVM 0.00007 0.00093

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**3D graphs:**



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