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% Part I: SIRD Modeling

% simulating the SIRD model from scratching w/o using pre-packaged MATLAB
% functions e.g. "lsim" and "ss"

x = [1, 0, 0, 0]'; % begin with the entire population susceptible

% define matrix elements outside the matrix for purposes of easier
% modification
ss = 0.95;  si = 0.04;  sr = 0;      sd = 0;
is = 0.05;  ii = 0.85;  ir = 0;      id = 0;
rs = 0;     ri = 0.1;   rr = 1;      rd = 0;
ds = 0;     di = 0.01;  dr = 0;      dd = 1;

A = [ss, si, sr, sd; is, ii, ir, id; rs, ri, rr, rd; ds, di, dr, dd];

Y = x; % day 1
for i = 2:300 % days 2 to convergence
    x = A * x;
    Y = [Y, x];
end

plot(Y' * 100, 'LineWidth', 2);
axis tight;
title('SIRD Model Simulated Manually');
legend('Susceptible', 'Infected', 'Recovered', 'Deceased');
xlabel('Elapsed Time (Days)');
ylabel('Percent of Total Population');
ytickformat('percentage');
exportgraphics(gca, 'SIRD.png');

% re-simulating the SIRD model but re-infections are possible i.e. a tiny
% portion of previously-infected individuals will go back to being
% susceptible even after already gaining immunity

x = [1, 0, 0, 0]'; % again, begin with the entire population susceptible

ss = 0.95;  si = 0.09;  sr = 0.01;  sd = 0;
is = 0.05;  ii = 0.85;  ir = 0;      id = 0;
rs = 0;     ri = 0.05;  rr = 0.99;  rd = 0;
ds = 0;     di = 0.01;  dr = 0;      dd = 1;

A = [ss, si, sr, sd; is, ii, ir, id; rs, ri, rr, rd; ds, di, dr, dd];

Y = x; % day 1
for i = 2:5000 % days 2 to convergence
    x = A * x;
    Y = [Y, x];
end

figure;
plot(Y' * 100, 'LineWidth', 2);

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axis tight;
title('Modified SIRD Model Simulated Manually');
legend('Susceptible', 'Infected', 'Recovered', 'Deceased');
xlabel('Elapsed Time (Days)');
ylabel('Percent of Total Population');
ytickformat('percentage');
exportgraphics(gca, 'SIRD_modified.png');

% Compared to the output of the manual implementation of the SIRD model in
% part1.m, implementation via pre-packaged MATLAB functions such as "lsim"
% and "ss" in base_sir.m are both concise and easy to modify different
% parameters. For example, changing a few values of lsim from the original

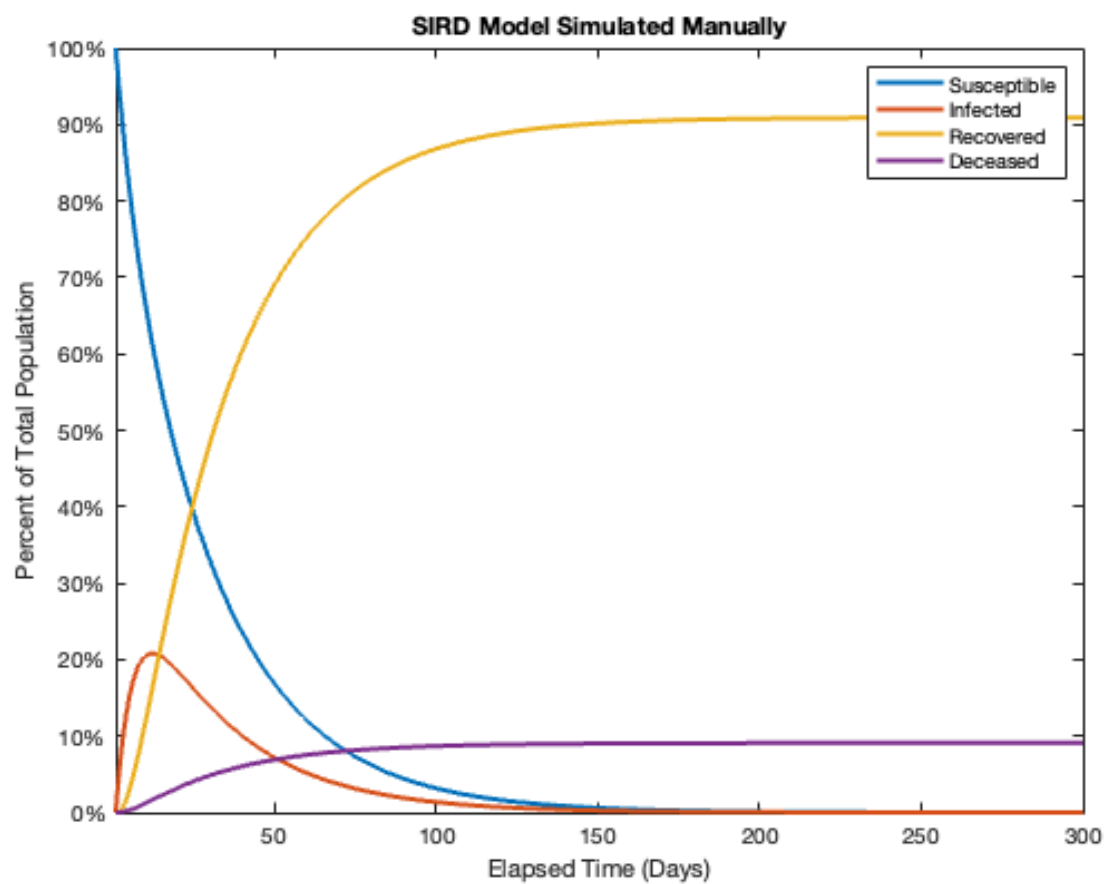
% lsim(sys_sir_base, zeros(1000, 1), linspace(0, 999, 1000), x0);

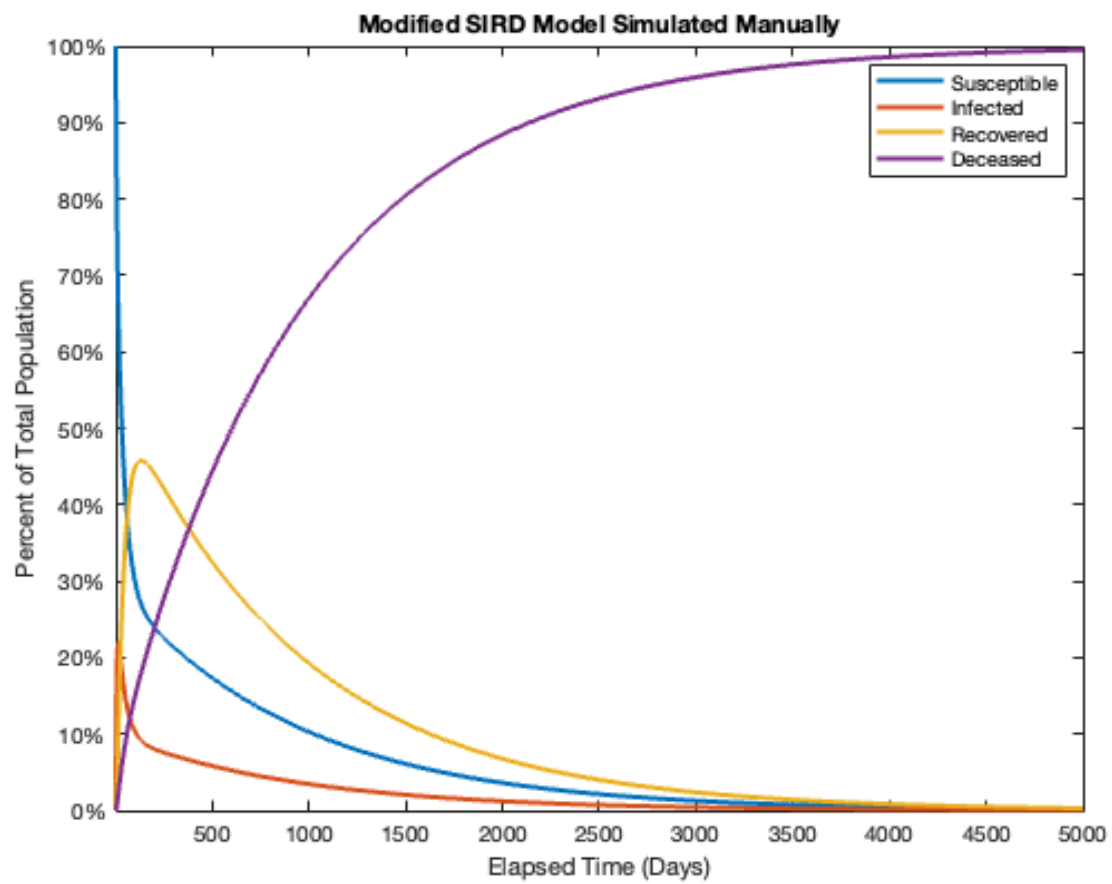
% to the current

% lsim(sys_sir_base, zeros(300, 1), linspace(0, 299, 300), x0);

% simulates the model in only 300 days instead of 1000, which is already
% sufficient given that the SIRD values graphically converge by the time
% 300 days have elapsed.

% The two methods require different approaches (pre-packaged functions vs.
% manual implementation) but arrive at the same result.
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