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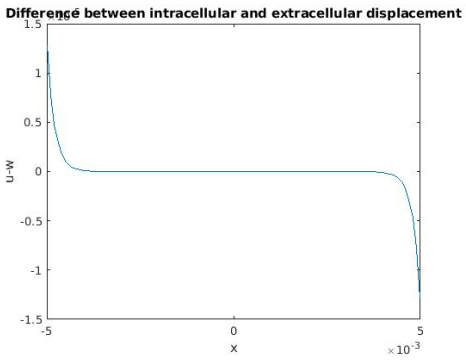
A computational study of mechanical bidomain model in durotaxis

Parameters

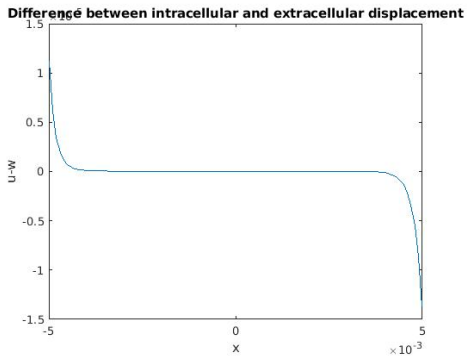
N = 101 (No of nodes)
L = 0.005 m (Length of domain)
nu = 1000 Pa (Intracellular modulus)
mu_zero = 1000 Pa (Extracellular modulus)
K = 50000000000 Pa/m^2 (Stiffness)
T = 200 Pa (Tension)

Code and Results

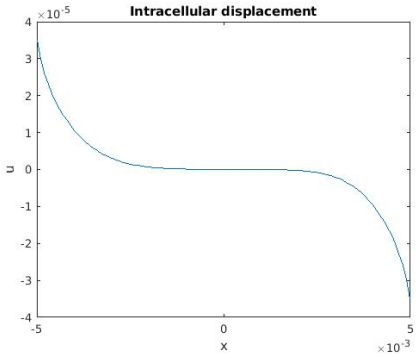
```
N = 101;
L = 0.005; %0.005m
g = 0; %100000; %100000 Pa/m
mu_zero = 1000; %1000 Pa
nu = 1000; %1000 Pa
K = 50000000000; %50GPa/m2
T = 200; %200Pa
w = zeros(N,1); %Extracellular displacement
u = zeros(N,1); %Intracellular displacement
x = zeros(N,1); %x position, useful when plotting
delta = (2*L)/(N-1); %Spacing along x direction
iterations = 100;
for i = 1:N
x(i) = L*(2*(i-1)/(N-1)-1);
mu(i) = mu_zero + g*x(i);
end
for k = 1:iterations
for i = 2:(N-1)
a(i) = 4*mu(i)*(w(i+1)+w(i-1))+(mu(i+1)-mu(i-1))*(w(i+1)-w(i-1));
b(i) = 4*nu*(u(i+1)+u(i-1));
A(i) = 8*mu(i) + K*delta*delta;
C = 8*nu + K*delta*delta;
B = K*delta*delta;
u(i) = (a(i)*B + A(i)*b(i))/(A(i)*C - B*B);
w(i) = (a(i)/A(i)) + (B/A(i))*((a(i)*B + A(i)*b(i))/(A(i)*C - B*B));
end
%Apply Boundary Conditions
u(1) = u(2) + (T*delta/(4*nu));
w(1) = w(2);
u(N) = u(N-1) - (T*delta/(4*nu));
w(N) = w(N-1);
end
for i = 1:N
h(i) = u(i)-w(i);
end
plot(x,h) %if you want plot with x in mm, use plot(x*1000,h)
xlabel('x');
ylabel('u-w');
title('Difference between extracellular and intracellular displacement');
```



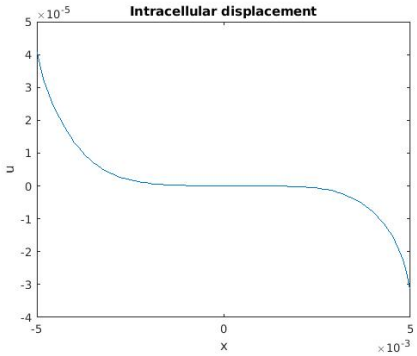
(a) Difference in displacements for g=0



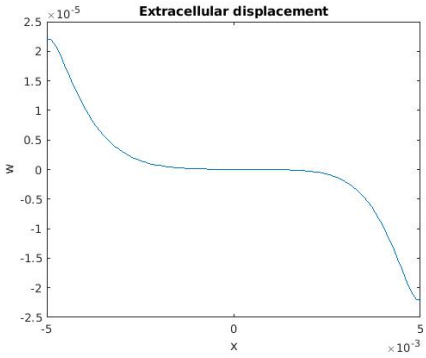
(b) Difference in displacements for g=10^5



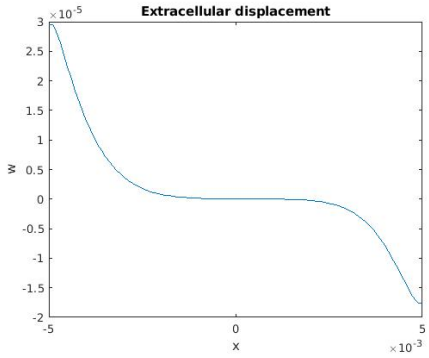
(c) Intracellular displacement for g=0



(d) Intracellular displacement for g=10^5

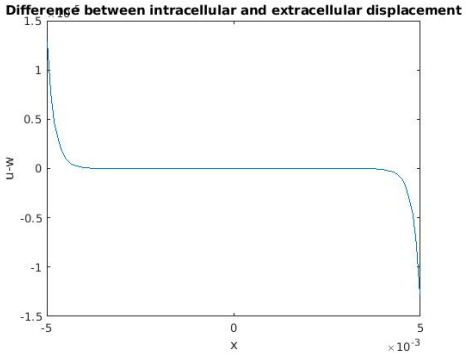


(e) Extracellular displacement for g=0

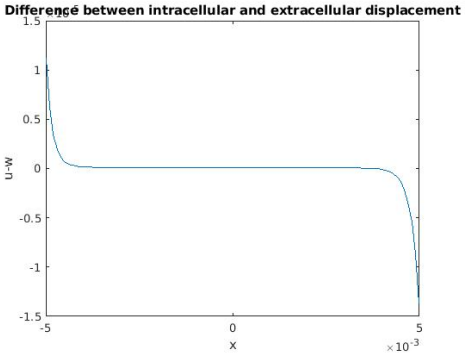


(f) Extracellular displacement for g=10^5

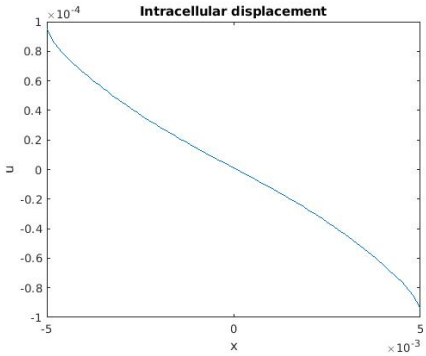
Figure 1: Comparison of results for g=0 and g=10^5 Pa/m (Iteration: 100). Elapsed time is 0.320051 seconds.



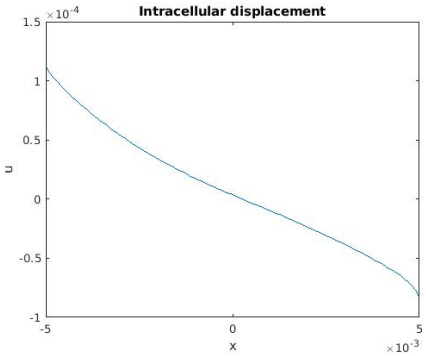
(a) Difference in displacements for g=0



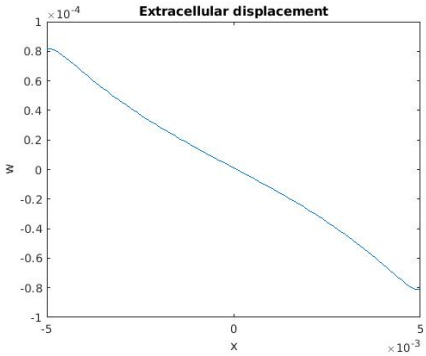
(b) Difference in displacements for g=10^5



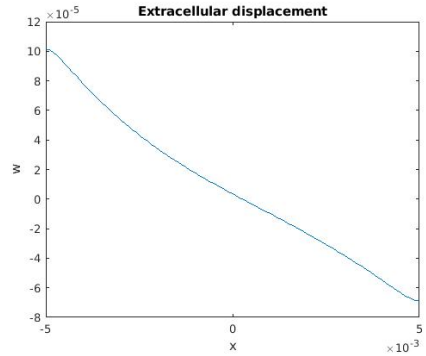
(c) Intracellular displacement for g=0



(d) Intracellular displacement for g=10^5

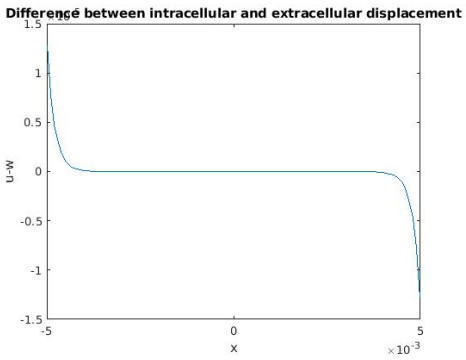


(e) Extracellular displacement for g=0

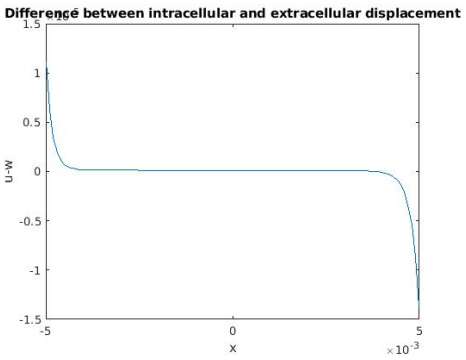


(f) Extracellular displacement for g=10^5

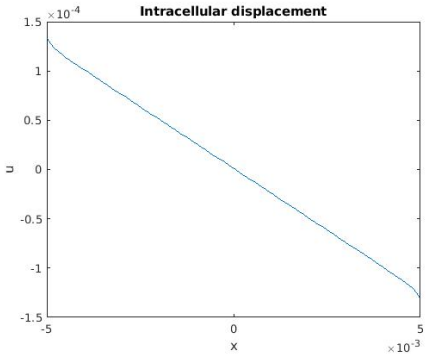
Figure 2: Comparison of results for g=0 and g=10^5 Pa/m (Iteration: 1000). Elapsed time is 0.366209 seconds.



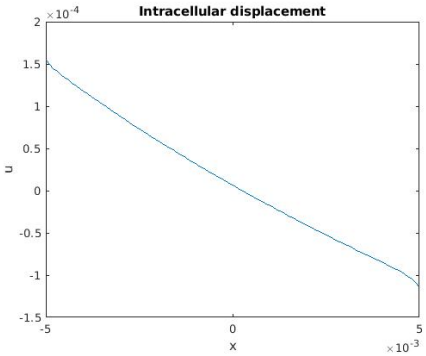
(a) Difference in displacements for g=0



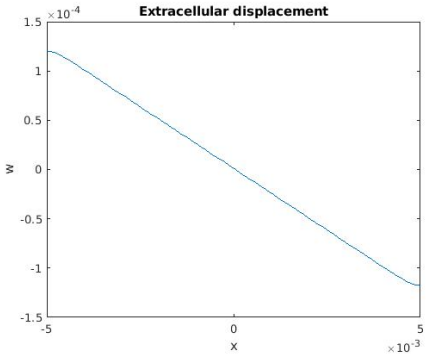
(b) Difference in displacements for g=10^5



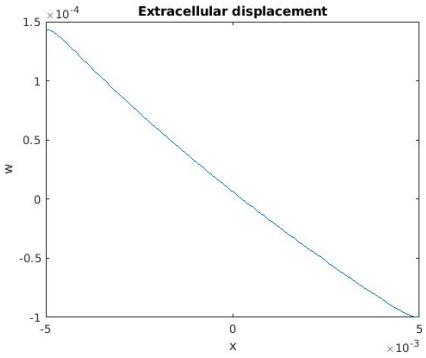
(c) Intracellular displacement for g=0



(d) Intracellular displacement for g=10^5

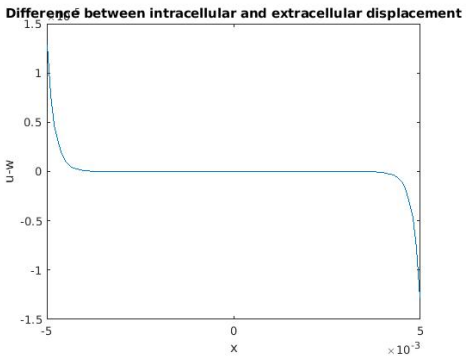


(e) Extracellular displacement for g=0

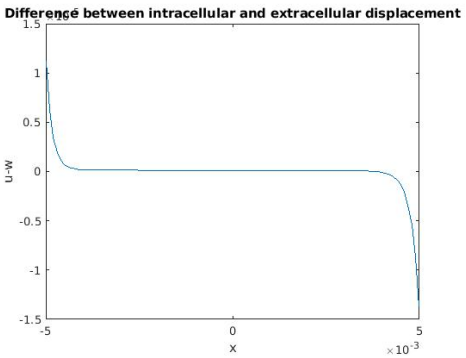


(f) Extracellular displacement for g=10^5

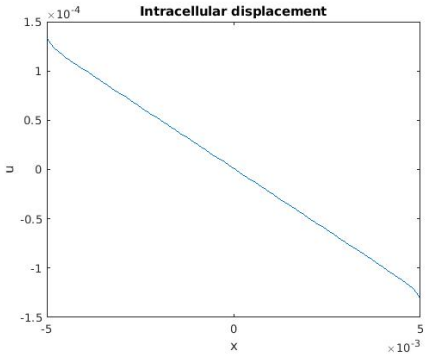
Figure 3: Comparison of results for g=0 and g=10^5 Pa/m (Iteration: 10000). Elapsed time is 0.414921 seconds.



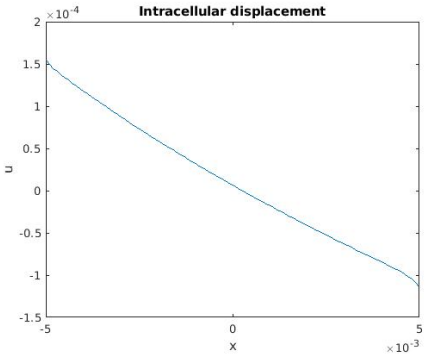
(a) Difference in displacements for g=0



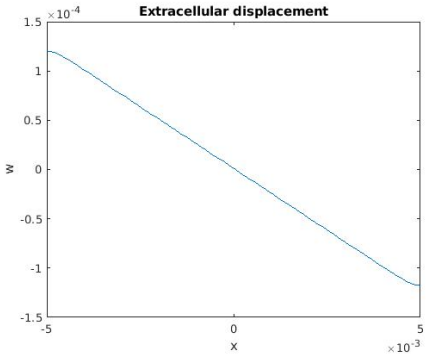
(b) Difference in displacements for g=10^5



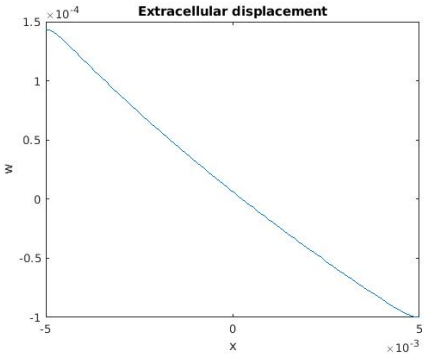
(c) Intracellular displacement for g=0



(d) Intracellular displacement for g=10^5

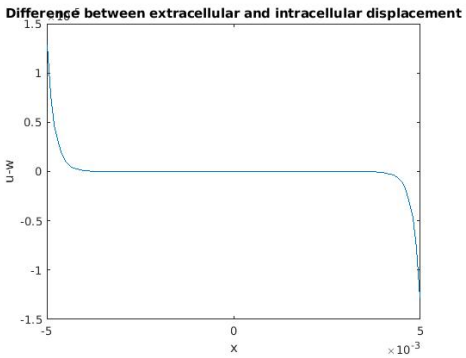


(e) Extracellular displacement for g=0

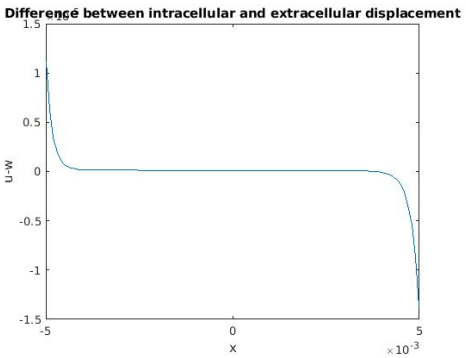


(f) Extracellular displacement for g=10^5

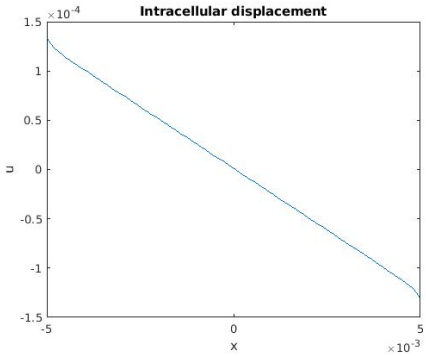
Figure 4: Comparison of results for g=0 and g=10^5 Pa/m (Iteration: 100000). Elapsed time is 0.772543 seconds.



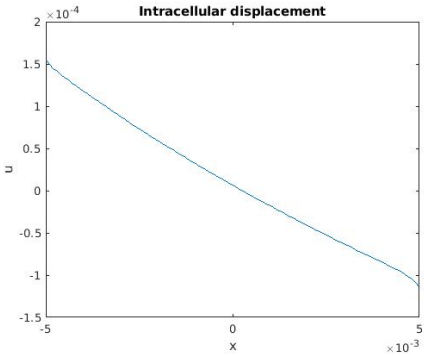
(a) Difference in displacements for g=0



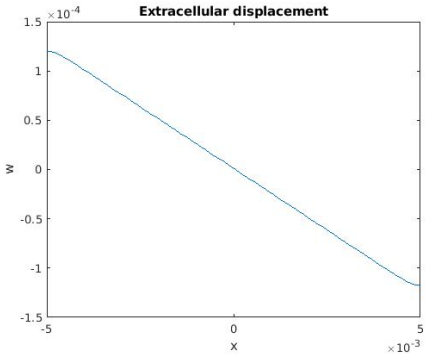
(b) Difference in displacements for g=10^5



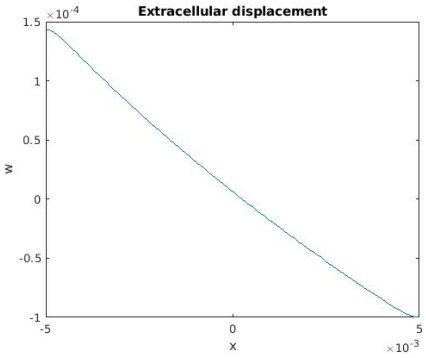
(c) Intracellular displacement for g=0



(d) Intracellular displacement for g=10^5



(e) Extracellular displacement for g=0



(f) Extracellular displacement for g=10^5

Figure 5: Comparison of results for g=0 and g=10^5 Pa/m (Iteration: 1000000). Elapsed time is 6.259795 seconds.

Difference of displacements as a function of stiffness gradient

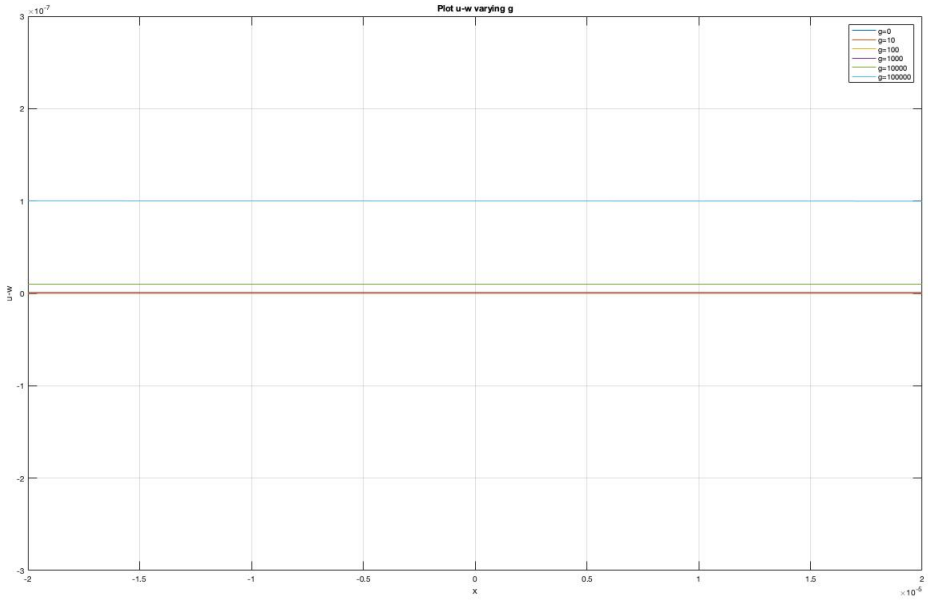


Figure 6: Difference in intracellular and extracellular displacements about x = 0 as a function of **g**

Over Relaxation

Variation of computation time with linearly increasing over relaxation parameter. The **stars** indicate the minimum value in each iteration limit. The figures below illustrate with iteration ranges from 10^2 to 10^4

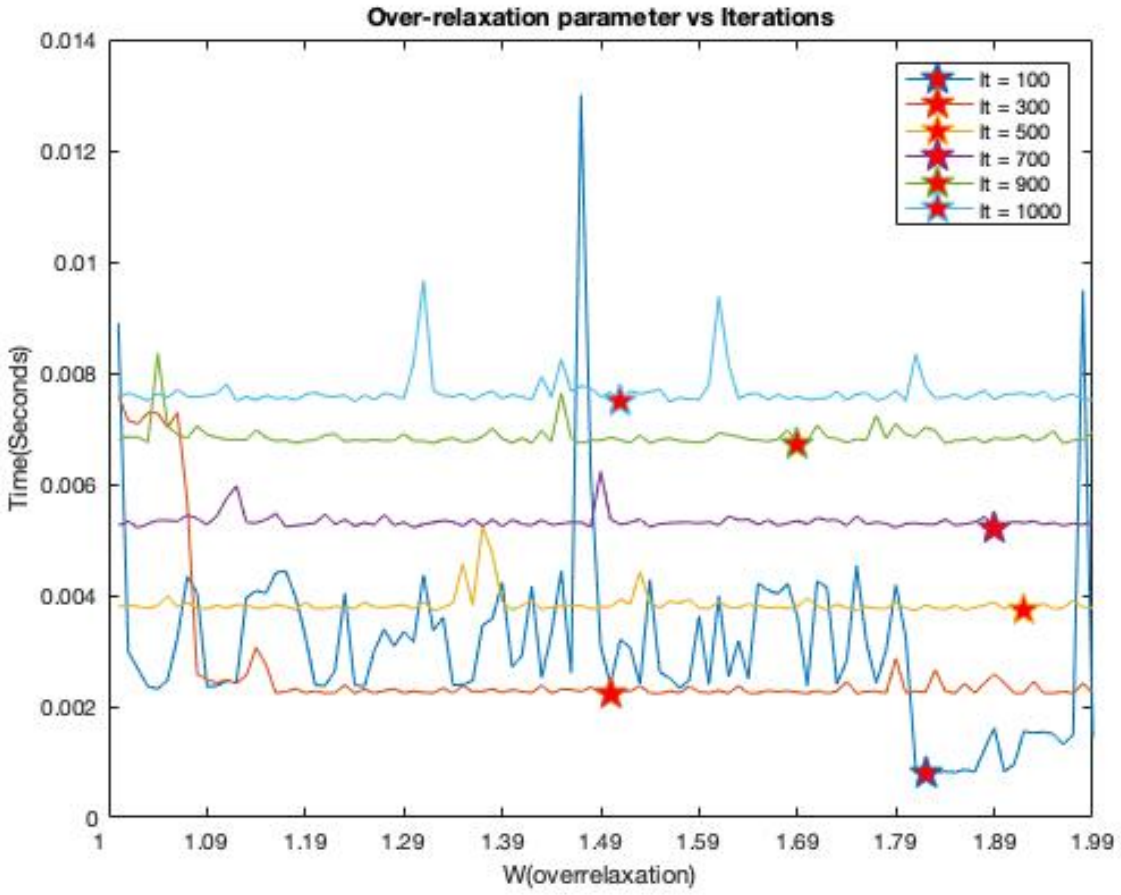


Figure 7: Iteration range: 100 - 1000

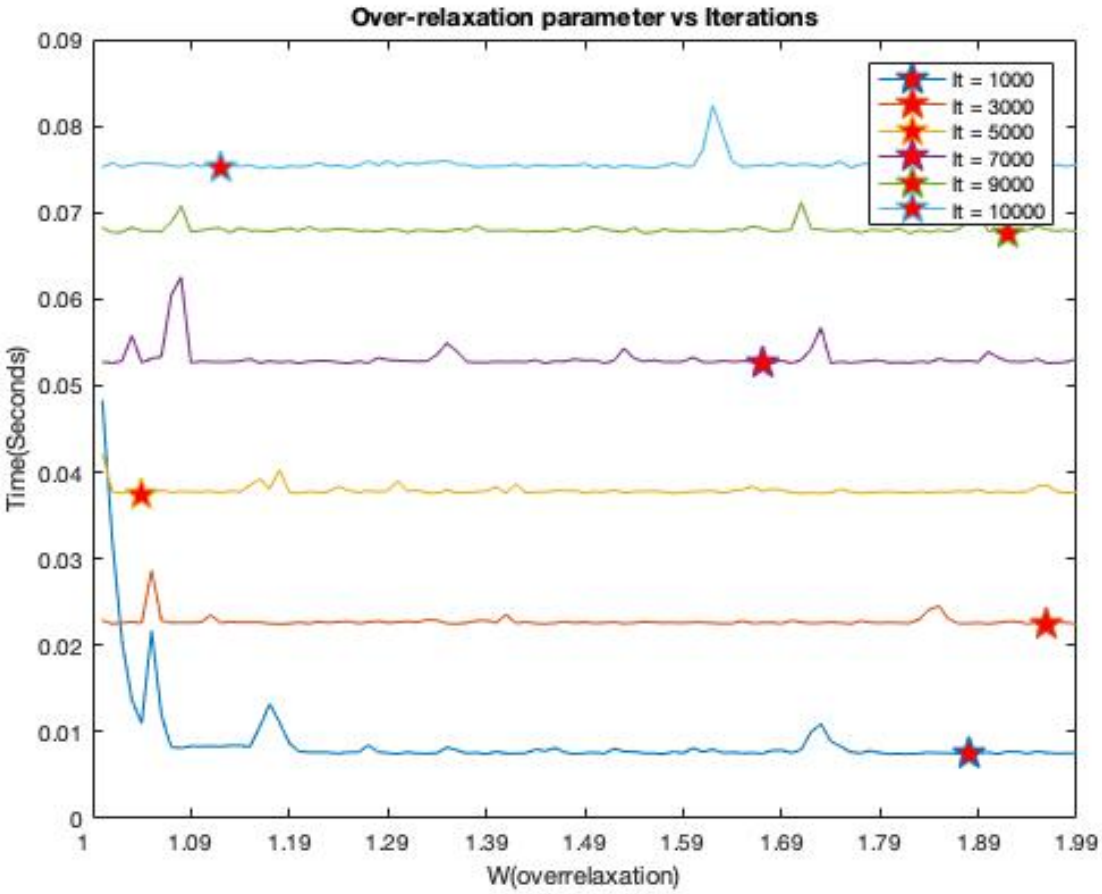


Figure 8: Iteration range: 1000 - 10000

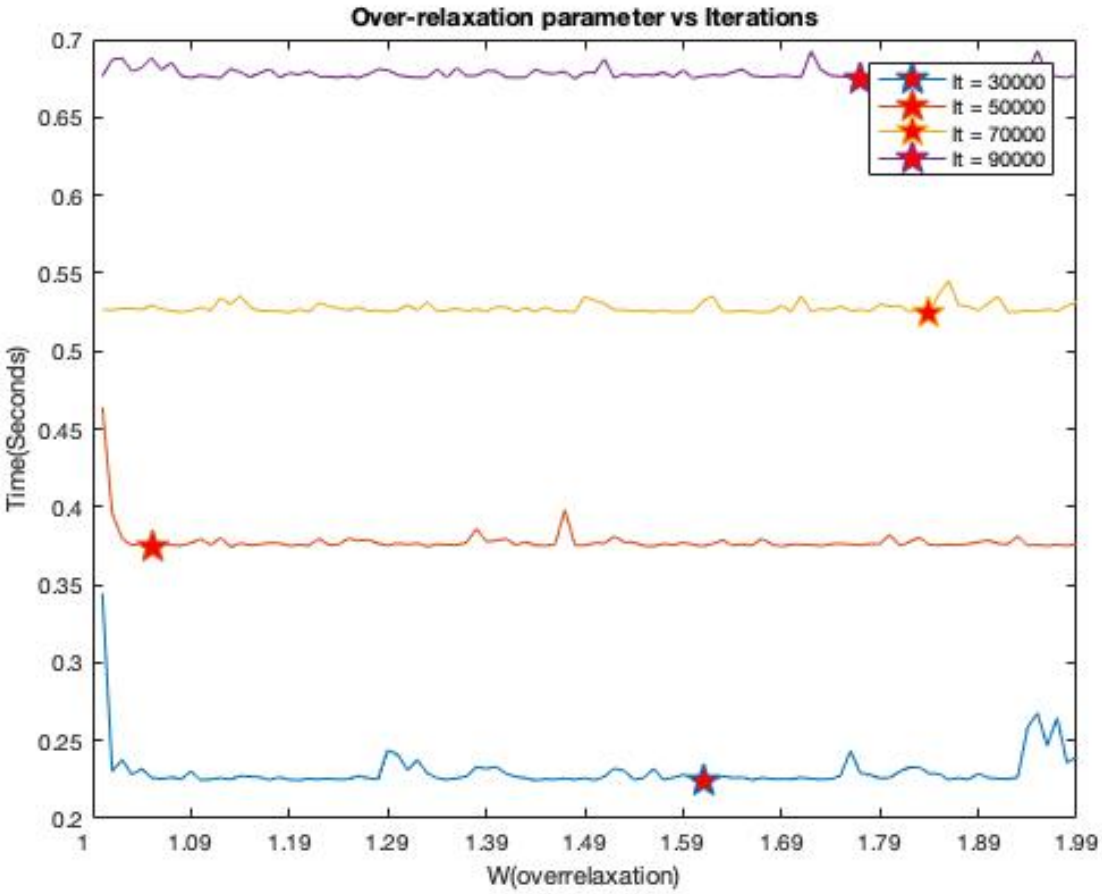


Figure 9: Iteration range: 30000 - 90000