Machine Learning in Critical Care

Lecture 2

A Quick Note about the Course

- **Session 1**
  - The Nature of Medical Data
  - Data Extraction via SQL
- **Session 2**
  - Algorithm Construction and Application
- **Session 3**
  - Feature Engineering
- **Session 4**
  - Apply your knowledge, win a prize, start a paper!
  - Doing the homework will help with this session!

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Session 2 - Learning Objectives

- Part 1: Build an intuition for how machine learning works
  - Data Pre-processing
  - Feature Selection
  - Model Construction

- Part 2: Apply a machine learning to a simple discriminative task
  - Model Validation

Your Homework For This Week

- **Problem 1:** Hand-craft an algorithm for predicting mortality in the patient population

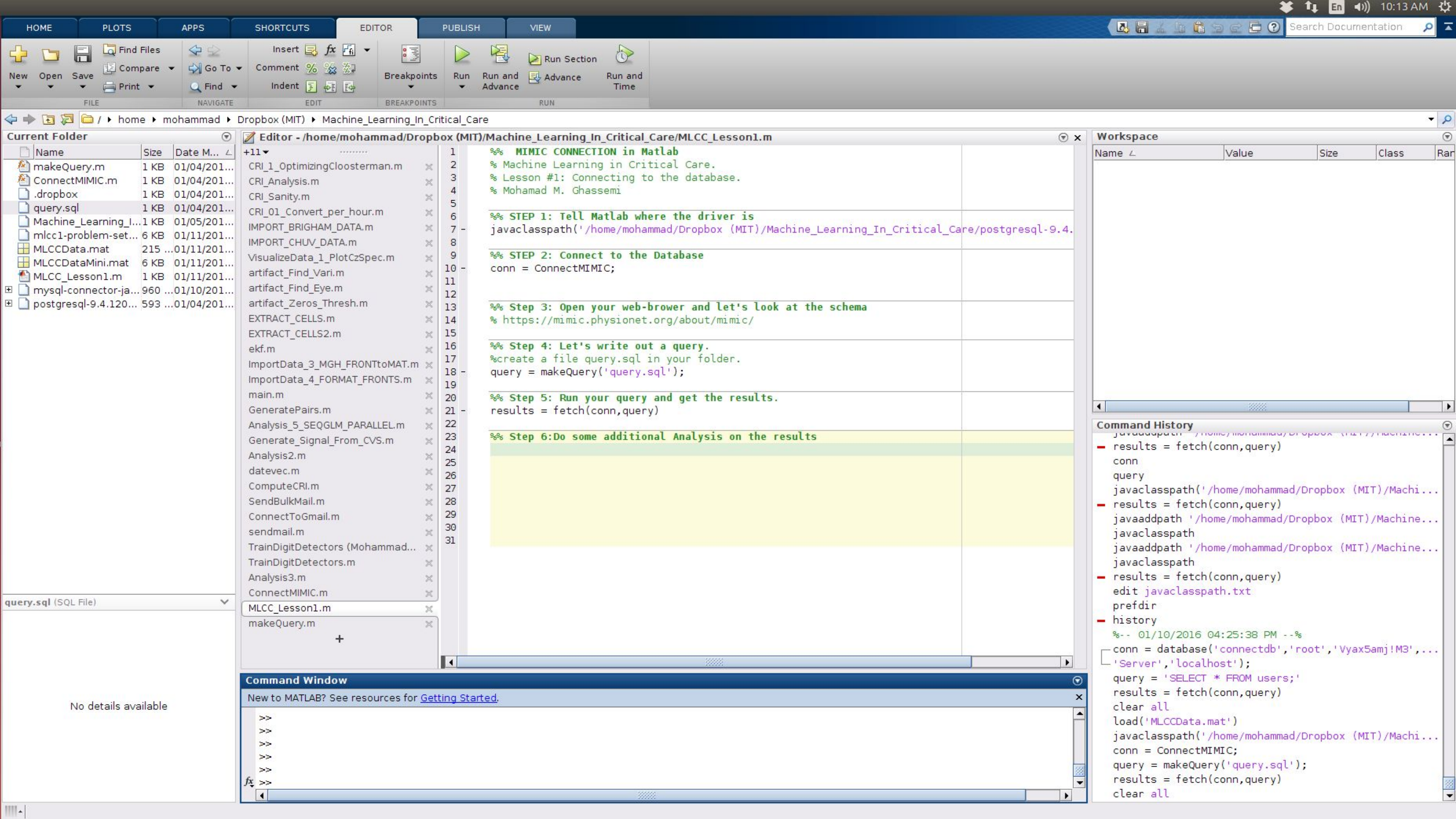
- **Problem 2:** Apply 3 machine learning techniques to predict patient mortality

Session 2, Part 1:

An Introduction to Human Learning

Download Resources:
http://bit.ly/1Rk0UnD

Overview of Matlab IDE



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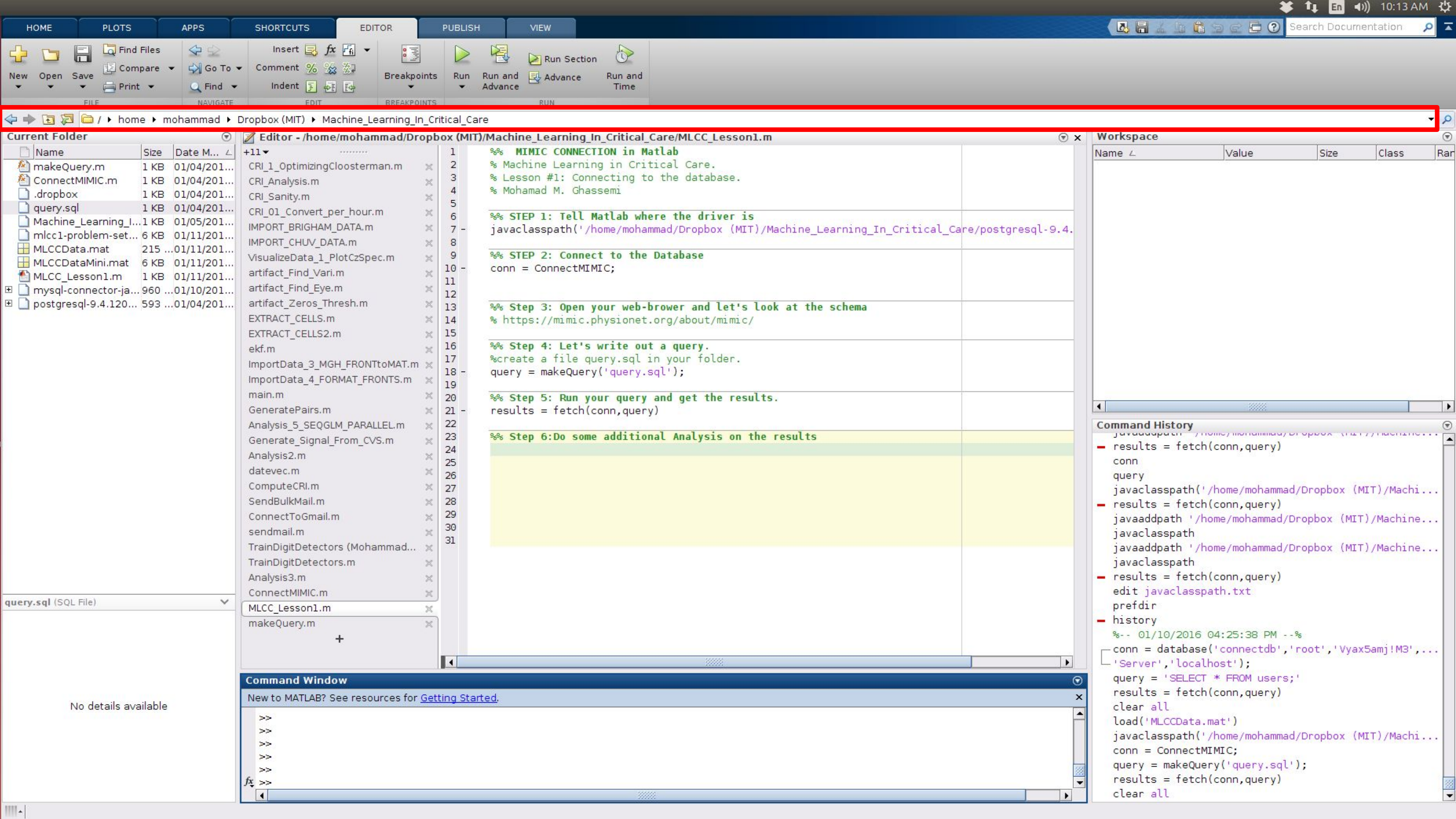

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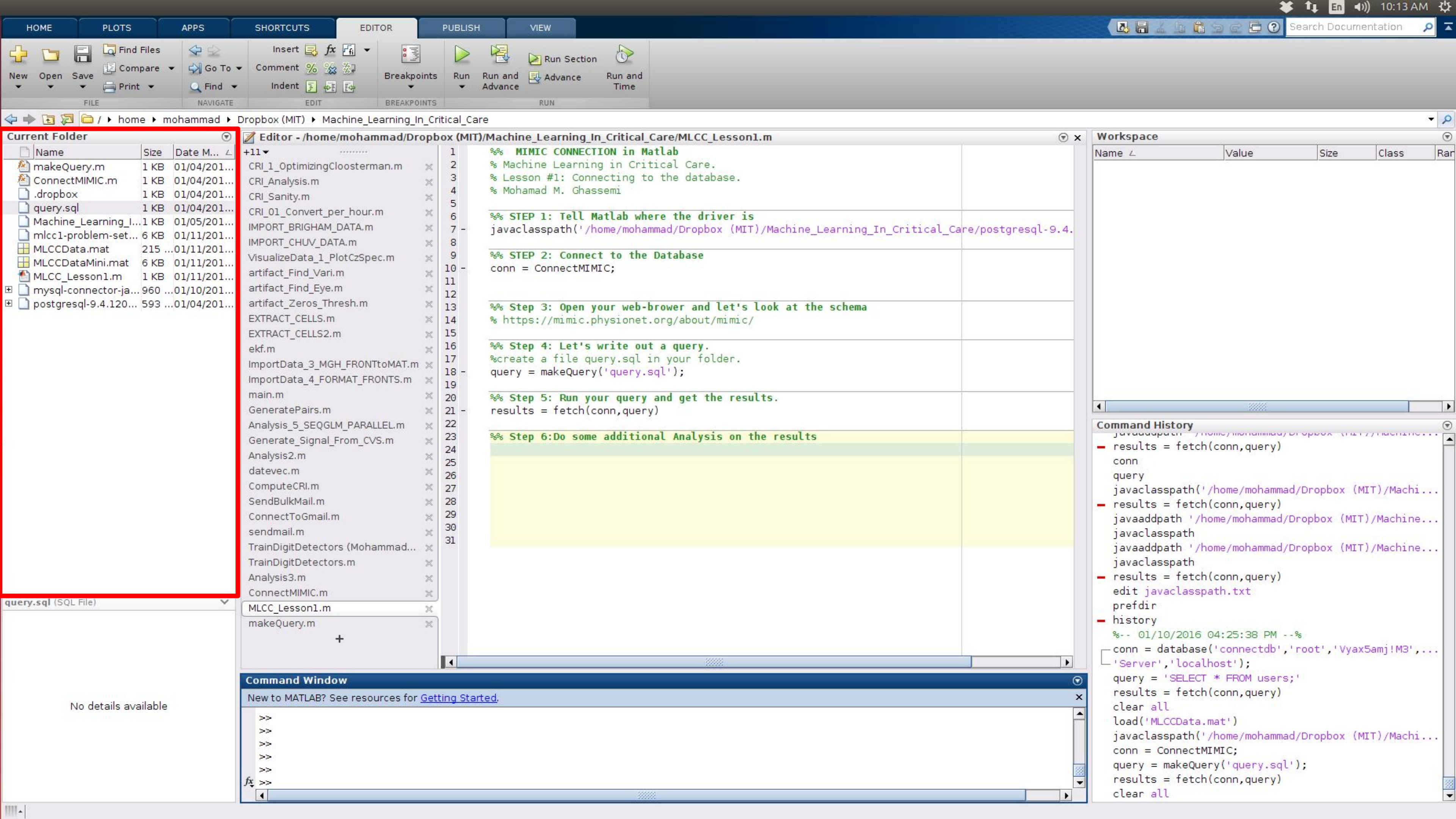

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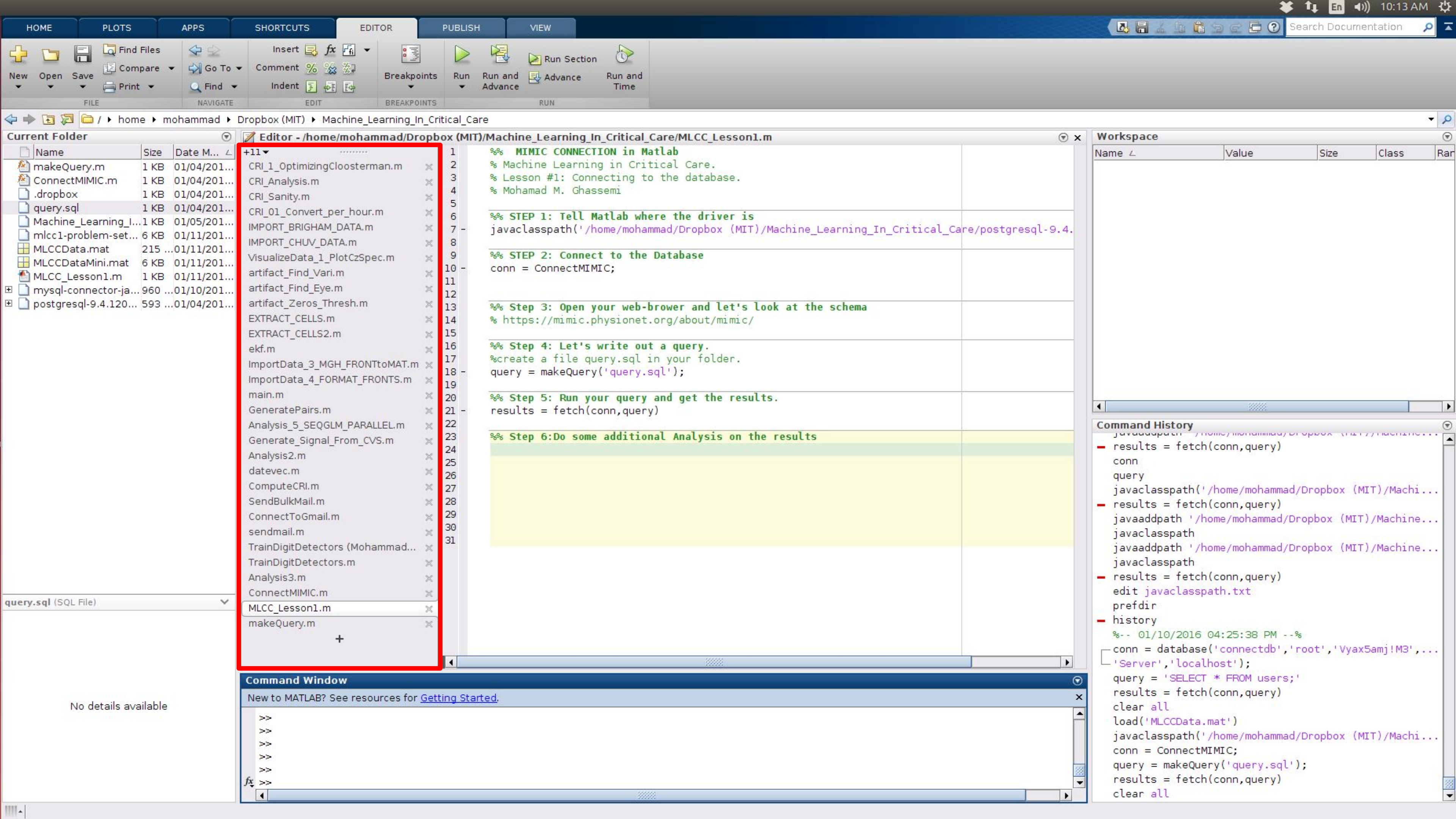
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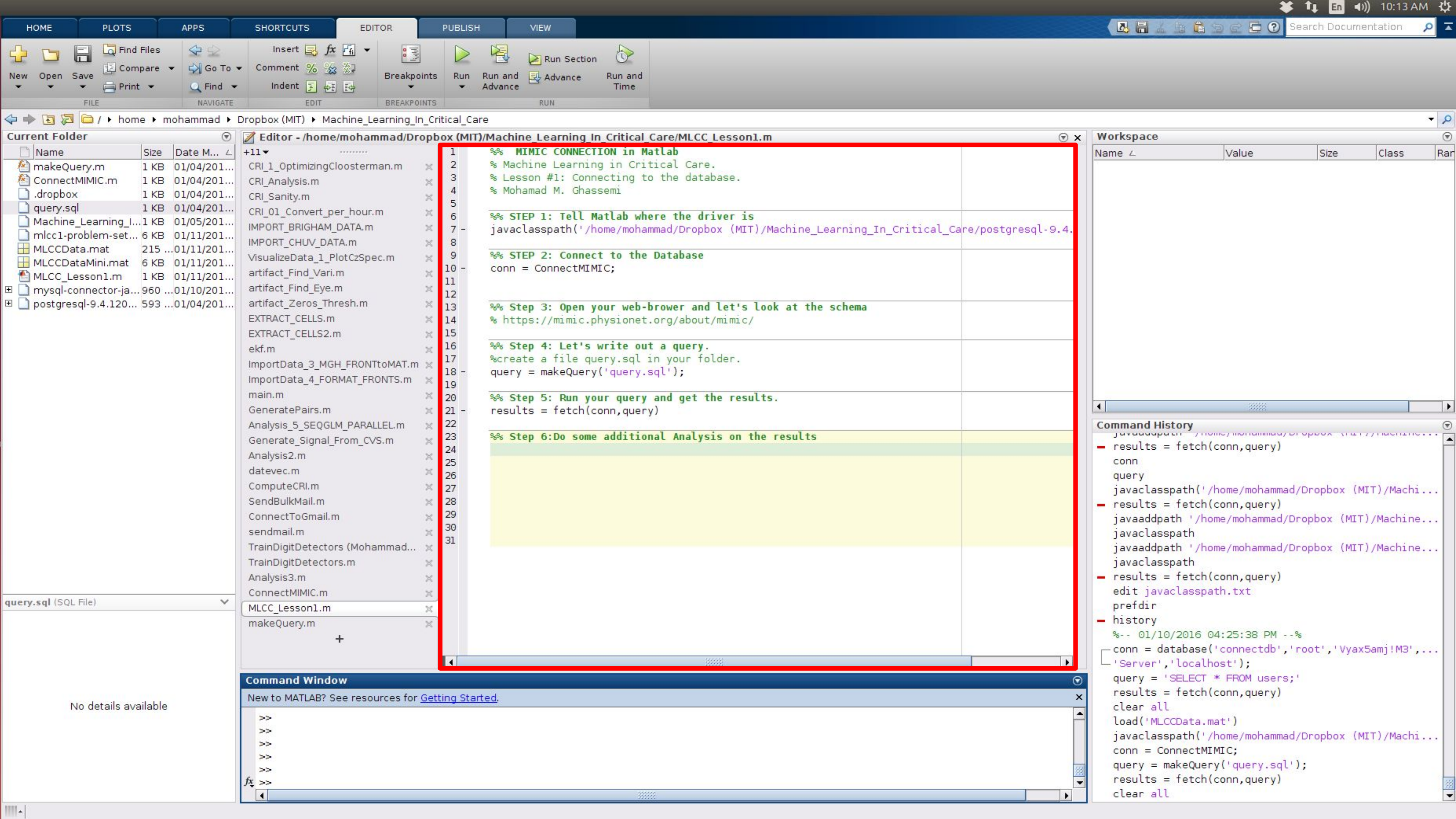
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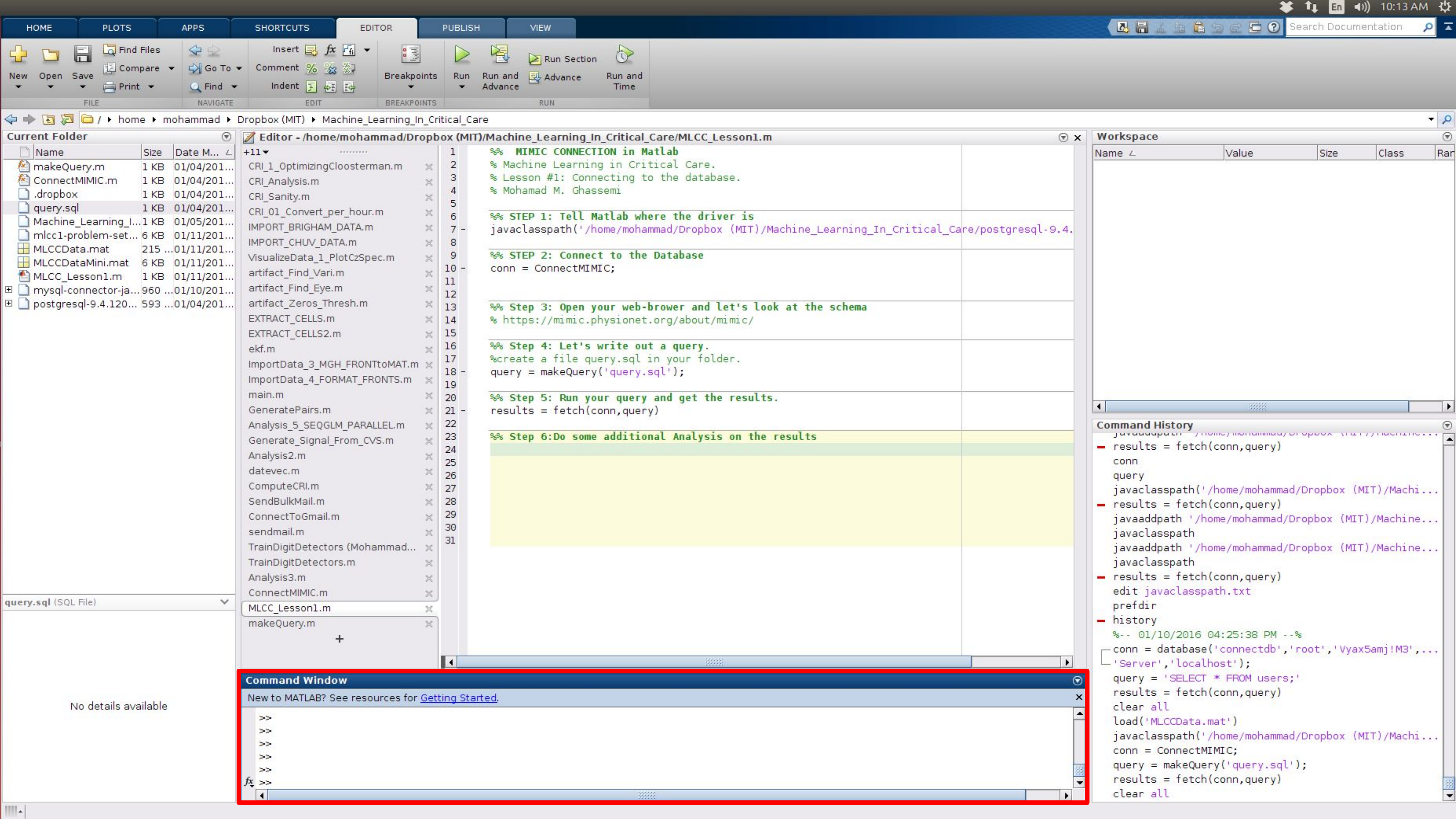
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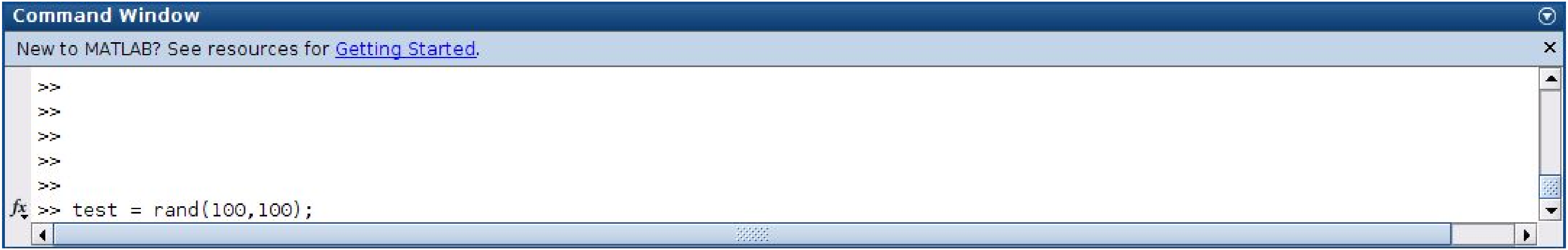
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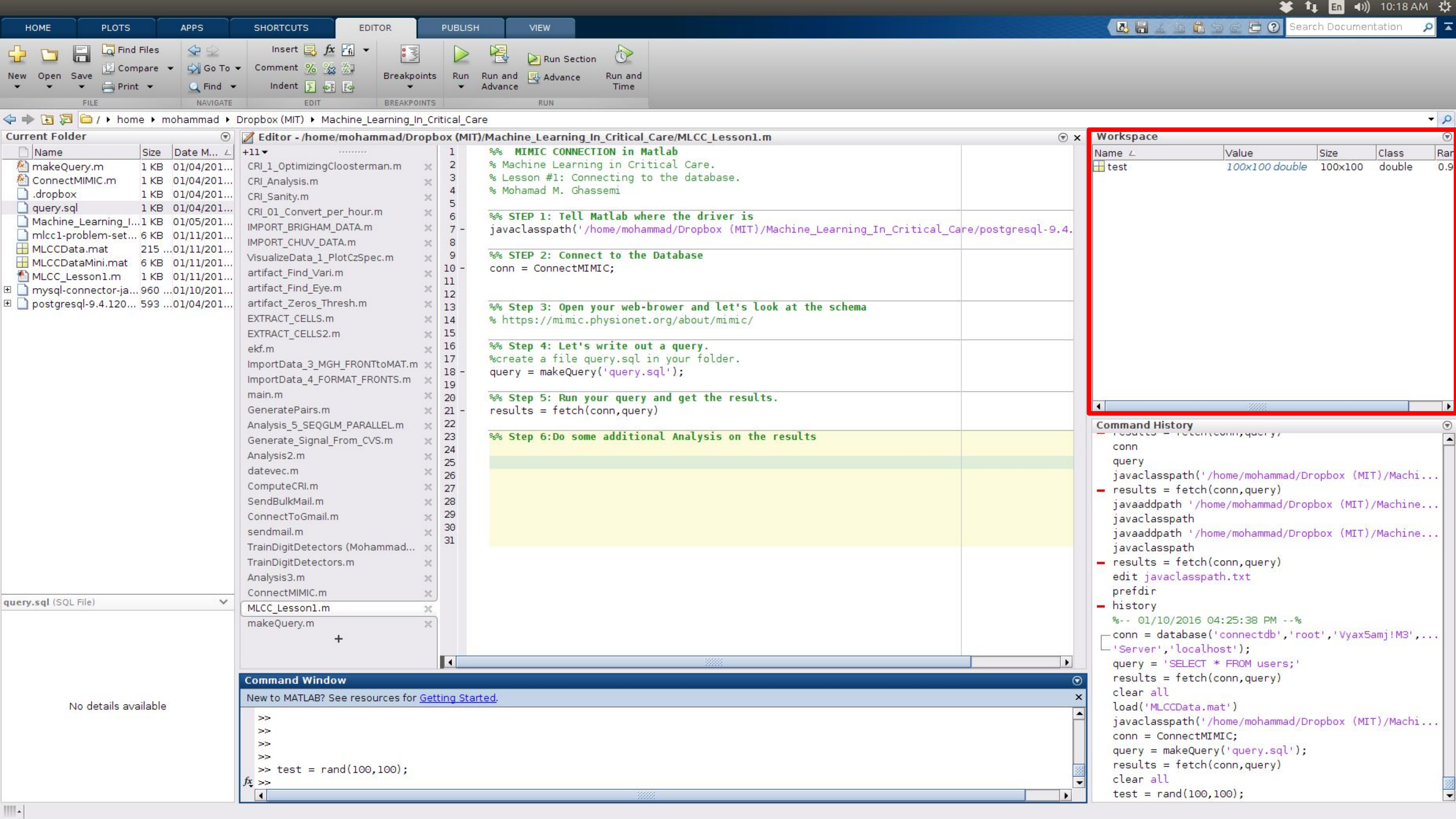
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artifact_Find_Vari.m
artifact_Find_Eye.m
artifact_Zeros_Thresh.m
EXTRACT_CELLS.m
EXTRACT_CELLS2.m
ekf.m
ImportData_3_MGH_FRONTtoMAT.m
ImportData_4_FORMAT_FRONTS.m
main.m
GeneratePairs.m
Analysis_5_SEQGLM_PARALLEL.m
Generate_Signal_From_CVS.m
Analysis2.m
datevec.m
ComputeCRI.m
SendBulkMail.m
ConnectToGmail.m
sendmail.m
TrainDigitDetectors (Mohammad...
TrainDigitDetectors.m
Analysis3.m
ConnectMIMIC.m
MLCC_Lesson1.m
makeQuery.m
%% MIMIC CONNECTION in Matlab
% Machine Learning in Critical Care.
% Lesson #1: Connecting to the database.
% Mohamad M. Ghassemi
%% STEP 1: Tell Matlab where the driver is
javaclasspath('/home/mohammad/Dropbox (MIT)/Machine_Learning_In_Critical_Care/postgresql-9.4.
%% STEP 2: Connect to the Database
conn = ConnectMIMIC;
%% Step 3: Open your web-brower and let's look at the schema
% https://mimic.physionet.org/about/mimic/
%% Step 4: Let's write out a query.
%create a file query.sql in your folder.
query = makeQuery('query.sql');
%% Step 5: Run your query and get the results.
results = fetch(conn,query)
%% Step 6:Do some additional Analysis on the results
Workspace
Name
Value
Size
Class
test 100x100 double 100x100 double
Command History
conn
query
javaclasspath('/home/mohammad/Dropbox (MIT)/Machi...
results = fetch(conn,query)
javaaddpath '/home/mohammad/Dropbox (MIT)/Machine...
javaclasspath
javaaddpath '/home/mohammad/Dropbox (MIT)/Machine...
javaclasspath
results = fetch(conn,query)
edit javaclasspath.txt
prefdir
history
%-- 01/10/2016 04:25:38 PM --%
conn = database('connectdb','root','Vyax5amj!M3',...
'Server','localhost');
query = 'SELECT * FROM users;'
results = fetch(conn,query)
clear all
load('MLCCData.mat')
javaclasspath('/home/mohammad/Dropbox (MIT)/Machi...
conn = ConnectMIMIC;
query = makeQuery('query.sql');
results = fetch(conn,query)
clear all
test = rand(100,100);
Command Window
New to MATLAB? See resources for Getting Started.
>> test = rand(100,100);

PLOTS | VARIABLE | VIEW

New from Selection | Open | Print | Rows 1 | Columns 1 | Insert | Delete | Transpose | Sort

VARIABLE | SELECTION | EDIT

test

100x100 double

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	0.8147	0.1622	0.6443	0.0596	0.4229	0.5822	0.8507	0.5590	0.6837	0.9879	0.6312	0.7829	0.5038	0.4067	0.5038	0.1403	0.6723	0.8383	0.1982	0.1934	0.7449	0.9852	0.0560
2	0.9058	0.7943	0.3786	0.6820	0.0942	0.5407	0.5606	0.8541	0.1321	0.1704	0.3551	0.6938	0.4896	0.6669	0.6128	0.2601	0.4315	0.5847	0.1951	0.7544	0.8923	0.5595	0.8169
3	0.1270	0.3112	0.8116	0.0424	0.5985	0.8699	0.9296	0.3479	0.7227	0.2578	0.9970	0.0098	0.8770	0.9337	0.8194	0.0868	0.6944	0.9481	0.3268	0.3463	0.2426	0.9336	0.5289
4	0.9134	0.5285	0.5328	0.0714	0.4709	0.2648	0.6967	0.4460	0.1104	0.3968	0.2242	0.8432	0.3531	0.8110	0.5319	0.4294	0.2568	0.0610	0.8803	0.4186	0.1296	0.7203	0.6944
5	0.6324	0.1656	0.3507	0.5216	0.6959	0.3181	0.5828	0.0542	0.1175	0.0740	0.6525	0.9223	0.4494	0.4845	0.2021	0.2573	0.0098	0.5846	0.4711	0.1557	0.2251	0.4840	0.2124
6	0.0975	0.6020	0.9390	0.0967	0.6999	0.1192	0.8154	0.1771	0.6407	0.6841	0.6050	0.7710	0.9635	0.7567	0.4539	0.2976	0.5323	0.2851	0.4040	0.8190	0.3500	0.6390	0.5433
7	0.2785	0.2630	0.8759	0.8181	0.6385	0.9398	0.8790	0.6628	0.3288	0.4024	0.3872	0.0427	0.0423	0.4170	0.4279	0.4249	0.2794	0.8277	0.1792	0.6249	0.2871	0.8876	0.7025
8	0.5469	0.6541	0.5502	0.8175	0.0336	0.6456	0.9889	0.3308	0.6538	0.9828	0.1422	0.3782	0.9730	0.9718	0.9661	0.1192	0.9462	0.1910	0.9689	0.7386	0.9275	0.1987	0.9564
9	0.9575	0.6892	0.6225	0.7224	0.0688	0.4795	5.2238e-...	0.8985	0.7491	0.4022	0.0251	0.7043	0.1892	0.9880	0.6201	0.4951	0.9064	0.4425	0.4075	0.8051	0.0513	0.3954	0.4445
10	0.9649	0.7482	0.5870	0.1499	0.3196	0.6393	0.8654	0.1182	0.5832	0.6207	0.4211	0.7295	0.6671	0.8641	0.6954	0.7064	0.3927	0.3934	0.8445	0.0672	0.5927	0.9922	0.0854
11	0.1576	0.4505	0.2077	0.6596	0.5309	0.5447	0.6126	0.9884	0.7400	0.1544	0.1841	0.2243	0.5864	0.3889	0.7202	0.2436	0.0249	0.8266	0.6153	0.9508	0.1629	0.4024	0.0573
12	0.9706	0.0838	0.3012	0.5186	0.6544	0.6473	0.9900	0.5400	0.2348	0.3813	0.7258	0.2691	0.6751	0.4547	0.3469	0.7851	0.6714	0.6769	0.3766	0.4976	0.8384	0.6589	0.6295
13	0.9572	0.2290	0.4709	0.9730	0.4076	0.5439	0.5277	0.7069	0.7350	0.1611	0.3704	0.6730	0.3610	0.2467	0.5170	0.0741	0.8372	0.2076	0.8772	0.7551	0.1676	0.9013	0.7962
14	0.4854	0.9133	0.2305	0.6490	0.8200	0.7210	0.4795	0.9995	0.9706	0.7581	0.8416	0.4775	0.6203	0.7844	0.5567	0.3939	0.9715	0.3181	0.7849	0.7424	0.5022	0.9954	0.6912
15	0.8003	0.1524	0.8443	0.8003	0.7184	0.5225	0.8013	0.2878	0.8669	0.8711	0.7342	0.6237	0.8112	0.8828	0.1565	0.0034	0.0569	0.1338	0.4650	0.8311	0.9993	0.6532	0.3453
16	0.1419	0.8258	0.1948	0.4538	0.9686	0.9937	0.2278	0.4145	0.0862	0.3508	0.5710	0.2364	0.0193	0.9137	0.5621	0.2207	0.4503	0.6715	0.8140	0.1565	0.3554	0.1084	0.9468
17	0.4218	0.5383	0.2259	0.4324	0.5313	0.2187	0.4981	0.4648	0.3664	0.6855	0.1769	0.1771	0.0839	0.5583	0.6948	0.0013	0.5825	0.5710	0.8984	0.4573	0.0471	0.0361	0.5202
18	0.9157	0.9961	0.1707	0.8253	0.3251	0.1058	0.9009	0.7640	0.3692	0.2941	0.9574	0.8296	0.9748	0.5989	0.4265	0.1892	0.6866	0.1698	0.4292	0.6181	0.2137	0.6181	0.9538
19	0.7922	0.0782	0.2277	0.0835	0.1056	0.1097	0.5747	0.8182	0.6850	0.5306	0.2653	0.7669	0.6513	0.1489	0.8363	0.1425	0.7194	0.1477	0.3343	0.9322	0.3978	0.5671	0.0736
20	0.9595	0.4427	0.4357	0.1332	0.6110	0.0636	0.8452	0.1002	0.5979	0.8324	0.9246	0.9345	0.2312	0.8997	0.7314	0.2681	0.6500	0.4761	0.5966	0.8351	0.3337	0.9620	0.2070
21	0.6557	0.1067	0.3111	0.1734	0.7788	0.4046	0.7386	0.1781	0.7894	0.5975	0.2238	0.1079	0.4035	0.4504	0.3600	0.1749	0.7269	0.9081	0.9020	0.8954	0.2296	0.7461	0.7750
22	0.0357	0.9619	0.9234	0.3909	0.4235	0.4484	0.5860	0.3596	0.3677	0.3353	0.3736	0.1822	0.1220	0.2057	0.4542	0.1386	0.3738	0.5522	0.7021	0.5825	0.9361	0.6625	0.9142
23	0.8491	0.0046	0.4302	0.8314	0.0908	0.3658	0.2467	0.0567	0.2060	0.2992	0.0875	0.0991	0.2684	0.8997	0.3864	0.5989	0.5816	0.0329	0.3775	0.5827	0.6832	0.5233	0.7826
24	0.9340	0.7749	0.1848	0.8034	0.2665	0.7635	0.6664	0.5219	0.0867	0.4526	0.6401	0.4898	0.2578	0.7626	0.7756	0.9011	0.1161	0.0539	0.7350	0.8549	0.9621	0.2599	0.2955
25	0.6787	0.8173	0.9049	0.0605	0.1537	0.6279	0.0835	0.3358	0.7719	0.4226	0.1806	0.1932	0.3317	0.8825	0.7343	0.9394	0.0577	0.8051	0.9541	0.0349	0.4380	0.9620	0.1518
26	0.7577	0.8687	0.9797	0.3993	0.2810	0.7720	0.6260	0.1757	0.2057	0.3596	0.0451	0.8959	0.1522	0.2850	0.4303	0.2212	0.9798	0.4514	0.5428	0.8854	0.9403	0.5402	0.8479
27	0.7431	0.0844	0.4389	0.5269	0.4401	0.9329	0.6609	0.2089	0.3883	0.5583	0.7232	0.0991	0.3480	0.6732	0.6938	0.4827	0.2848	0.3826	0.5401	0.4077	0.0058	0.0303	0.7849
28	0.3922	0.3998	0.1111	0.4168	0.5271	0.9727	0.7298	0.9052	0.5518	0.7425	0.3474	0.0442	0.1217	0.6643	0.9452	0.3760	0.5950	0.7896	0.3111	0.0364	0.6103	0.6963	0.2708
29	0.6555	0.2599	0.2581	0.6569	0.4574	0.1920	0.8908	0.6754	0.2290	0.4243	0.6606	0.5573	0.8842	0.1228	0.7842	0.5238	0.9622	0.3643	0.0712	0.7461	0.8011	0.5197	0.2278
30	0.1712	0.8001	0.4087	0.6280	0.8754	0.1389	0.9823	0.4685	0.6419	0.4294	0.3839	0.7725	0.0943	0.4073	0.7056	0.2649	0.1858	0.5323	0.1820	0.1548	0.2330	0.0590	0.3210
31	0.7060	0.4314	0.5949	0.2920	0.5181	0.6963	0.7690	0.9121	0.4845	0.1249	0.6273	0.3119	0.9300	0.2753	0.1093	0.0684	0.1930	0.7117	0.0930	0.1439	0.9325	0.8900	0.8296
32	0.0318	0.9106	0.2622	0.4317	0.9436	0.0938	0.5814	0.1040	0.1518	0.0244	0.0216	0.1790	0.3990	0.7167	0.3899	0.4363	0.3416	0.8715	0.4635	0.6060	0.7633	0.3302	0.8222
33	0.2769	0.1818	0.6028	0.0155	0.6377	0.5254	0.9283	0.7455	0.7819	0.2902	0.9106	0.3390	0.0474	0.2834	0.5909	0.1739	0.9329	0.3287	0.0093	0.2545	0.8264	0.2297	0.5707
34	0.0462	0.2638	0.7112	0.9841	0.9577	0.5303	0.5801	0.7363	0.1006	0.3175	0.8006	0.2101	0.3424	0.8962	0.4594	0.0261	0.3907	0.6501	0.9150	0.3242	0.5735	0.1139	0.5718
35	0.0971	0.1455	0.2217	0.1672	0.2407	0.8611	0.0170	0.5619	0.2941	0.6537	0.7458	0.5102	0.7360	0.8266	0.0503	0.9547	0.2732	0.9748	0.6427	0.4018	0.7926	0.3109	0.2860
36	0.8235	0.1361	0.1174	0.1062	0.6761	0.4849	0.1209	0.1842	0.2374	0.9569	0.8131	0.9064	0.7947	0.3900	0.2287	0.4306	0.1519	0.0760	0.0014	0.4064	0.3290	0.2284	0.6991
37	0.6948	0.8693	0.2967	0.3724	0.2891	0.3935	0.8627	0.5972	0.5309	0.9357	0.3833	0.6289	0.5449	0.4979	0.8342	0.9616	0.3971	0.5870	0.0304	0.3862	0.2235	0.6520	0.7963
38	0.3171	0.5797	0.3188	0.1981	0.6718	0.6714	0.4843	0.2999	0.0915	0.4579	0.6173	0.1015	0.6862	0.6948	0.0156	0.7624	0.3747	0.4139	0.2085	0.6098	0.3124	0.0662	0.4416
39	0.9502	0.5499	0.4242	0.4897	0.6951	0.7413	0.8449	0.1341	0.4053	0.2405	0.5755	0.3909	0.8936	0.8344	0.8637	0.0073	0.1311	0.3091	0.4550	0.1669	0.5845	0.2754	0.4462
40	0.0344	0.1450	0.5079	0.3395	0.0680	0.5201	0.2094	0.2126	0.1048	0.7639	0.5301	0.0546	0.0548	0.6096	0.0781	0.6800	0.4350	0.2638	0.1273	0.1881	0.8299	0.2818	0.4657

s - test

10:32 AM

PLOTS | VARIABLE | VIEW

test(:,1)

SELECTION

plot | bar | area | pie | histogram | semilogx | semilogy | loglog | comet | stem | stairs | barh

PLOTS: test(:,1)

Reuse Figure

New Figure

OPTIONS

test

100x100 double

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
3	0.1270	0.3112	0.8116	0.0424	0.5985	0.8699	0.9296	0.3479	0.7227	0.2578	0.9970	0.0098	0.8770	0.9337	0.8194	0.0868	0.6944	0.9481	0.3268	0.3463	0.2426	0.9336	0.5289
4	0.9134	0.5285	0.5328	0.0714	0.4709	0.2648	0.6967	0.4460	0.1104	0.3968	0.2242	0.8432	0.3531	0.8110	0.5319	0.4294	0.2568	0.0610	0.8803	0.4186	0.1296	0.7203	0.6944
5	0.6324	0.1656	0.3507	0.5216	0.6959	0.3181	0.5828	0.0542	0.1175	0.0740	0.6525	0.9223	0.4494	0.4845	0.2021	0.2573	0.0098	0.5846	0.4711	0.1557	0.2251	0.4840	0.2124
6	0.0975	0.6020	0.9390	0.0967	0.6999	0.1192	0.8154	0.1771	0.6407	0.6841	0.6050	0.7710	0.9635	0.7567	0.4539	0.2976	0.5323	0.2851	0.4040	0.8190	0.3500	0.6390	0.5433
7	0.2785	0.2630	0.8759	0.8181	0.6385	0.9398	0.8790	0.6628	0.3288	0.4024	0.3872	0.0427	0.0423	0.4170	0.4279	0.4249	0.2794	0.8277	0.1792	0.6249	0.2871	0.8876	0.7025
8	0.5469	0.6541	0.5502	0.8175	0.0336	0.6456	0.9889	0.3308	0.6538	0.9828	0.1422	0.3782	0.9730	0.9718	0.9661	0.1192	0.9462	0.1910	0.9689	0.7386	0.9275	0.1987	0.9564
9	0.9575	0.6892	0.6225	0.7224	0.0688	0.4795	5.2238e-...	0.8985	0.7491	0.4022	0.0251	0.7043	0.1892	0.9880	0.6201	0.4951	0.9064	0.4425	0.4075	0.8051	0.0513	0.3954	0.4445
10	0.9649	0.7482	0.5870	0.1499	0.3196	0.6393	0.8654	0.1182	0.5832	0.6207	0.4211	0.7295	0.6671	0.8641	0.6954	0.7064	0.3927	0.3934	0.8445	0.0672	0.5927	0.9922	0.0854
11	0.1576	0.4505	0.2077	0.6596	0.5309	0.5447	0.6126	0.9884	0.7400	0.1544	0.1841	0.2243	0.5864	0.3889	0.7202	0.2436	0.0249	0.8266	0.6153	0.9508	0.1629	0.4024	0.0573
12	0.9706	0.0838	0.3012	0.5186	0.6544	0.6473	0.9900	0.5400	0.2348	0.3813	0.7258	0.2691	0.6751	0.4547	0.3469	0.7851	0.6714	0.6769	0.3766	0.4976	0.8384	0.6589	0.6295
13	0.9572	0.2290	0.4709	0.9730	0.4076	0.5439	0.5277	0.7069	0.7350	0.1611	0.3704	0.6730	0.3610	0.2467	0.5170	0.0741	0.8372	0.2076	0.8772	0.7551	0.1676	0.9013	0.7962
14	0.4854	0.9133	0.2305	0.6490	0.8200	0.7210	0.4795	0.9995	0.9706	0.7581	0.8416	0.4775	0.6203	0.7844	0.5567	0.3939	0.9715	0.3181	0.7849	0.7424	0.5022	0.9954	0.6912
15	0.8003	0.1524	0.8443	0.8003	0.7184	0.5225	0.8013	0.2878	0.8669	0.8711	0.7342	0.6237	0.8112	0.8828	0.1565	0.0034	0.0569	0.1338	0.4650	0.8311	0.9993	0.6532	0.3453
16	0.1419	0.8258	0.1948	0.4538	0.9686	0.9937	0.2278	0.4145	0.0862	0.3508	0.5710	0.2364	0.0193	0.9137	0.5621	0.2207	0.4503	0.6715	0.8140	0.1565	0.3554	0.1084	0.9468
17	0.4218	0.5383	0.2259	0.4324	0.5313	0.2187	0.4981	0.4648	0.3664	0.6855	0.1769	0.1771	0.0839	0.5583	0.6948	0.0013	0.5825	0.5710	0.8984	0.4573	0.0471	0.0361	0.5202
18	0.9157	0.9961	0.1707	0.8253	0.3251	0.1058	0.9009	0.7640	0.3692	0.2941	0.9574	0.8296	0.9748	0.5989	0.4265	0.1892	0.6866	0.1698	0.4292	0.6181	0.2137	0.6181	0.9538
19	0.7922	0.0782	0.2277	0.0835	0.1056	0.1097	0.5747	0.8182	0.6850	0.5306	0.2653	0.7669	0.6513	0.1489	0.8363	0.1425	0.7194	0.1477	0.3343	0.9322	0.3978	0.5671	0.0736
20	0.9595	0.4427	0.4357	0.1332	0.6110	0.0636	0.8452	0.1002	0.5979	0.8324	0.9246	0.9345	0.2312	0.8997	0.7314	0.2681	0.6500	0.4761	0.5966	0.8351	0.3337	0.9620	0.2070
21	0.6557	0.1067	0.3111	0.1734	0.7788	0.4046	0.7386	0.1781	0.7894	0.5975	0.2238	0.1079	0.4035	0.4504	0.3600	0.1749	0.7269	0.9081	0.9020	0.8954	0.2296	0.7461	0.7750
22	0.0357	0.9619	0.9234	0.3909	0.4235	0.4484	0.5860	0.3596	0.3677	0.3353	0.3736	0.1822	0.1220	0.2057	0.4542	0.1386	0.3738	0.5522	0.7021	0.5825	0.9361	0.6625	0.9142
23	0.8491	0.0046	0.4302	0.8314	0.0908	0.3658	0.2467	0.0567	0.2060	0.2992	0.0875	0.0991	0.2684	0.8997	0.3864	0.5989	0.5816	0.0329	0.3775	0.5827	0.6832	0.5233	0.7826
24	0.9340	0.7749	0.1848	0.8034	0.2665	0.7635	0.6664	0.5219	0.0867	0.4526	0.6401	0.4898	0.2578	0.7626	0.7756	0.9011	0.1161	0.0539	0.7350	0.8549	0.9621	0.2599	0.2955
25	0.6787	0.8173	0.9049	0.0605	0.1537	0.6279	0.0835	0.3358	0.7719	0.4226	0.1806	0.1932	0.3317	0.8825	0.7343	0.9394	0.0577	0.8051	0.9541	0.0349	0.4380	0.9620	0.1518
26	0.7577	0.8687	0.9797	0.3993	0.2810	0.7720	0.6260	0.1757	0.2057	0.3596	0.0451	0.8959	0.1522	0.2850	0.4303	0.2212	0.9798	0.4514	0.5428	0.8854	0.9403	0.5402	0.8479
27	0.7431	0.0844	0.4389	0.5269	0.4401	0.9329	0.6609	0.2089	0.3883	0.5583	0.7232	0.0991	0.3480	0.6732	0.6938	0.4827	0.2848	0.3826	0.5401	0.4077	0.0058	0.0303	0.7849
28	0.3922	0.3998	0.1111	0.4168	0.5271	0.9727	0.7298	0.9052	0.5518	0.7425	0.3474	0.0442	0.1217	0.6643	0.9452	0.3760	0.5950	0.7896	0.3111	0.0364	0.6103	0.6963	0.2708
29	0.6555	0.2599	0.2581	0.6569	0.4574	0.1920	0.8908	0.6754	0.2290	0.4243	0.6606	0.5573	0.8842	0.1228	0.7842	0.5238	0.9622	0.3643	0.0712	0.7461	0.8011	0.5197	0.2278
30	0.1712	0.8001	0.4087	0.6280	0.8754	0.1389	0.9823	0.4685	0.6419	0.4294	0.3839	0.7725	0.0943	0.4073	0.7056	0.2649	0.1858	0.5323	0.1820	0.1548	0.2330	0.0590	0.3210
31	0.7060	0.4314	0.5949	0.2920	0.5181	0.6963	0.7690	0.9121	0.4845	0.1249	0.6273	0.3119	0.9300	0.2753	0.1093	0.0684	0.1930	0.7117	0.0930	0.1439	0.9325	0.8900	0.8296
32	0.0318	0.9106	0.2622	0.4317	0.9436	0.0938	0.5814	0.1040	0.1518	0.0244	0.0216	0.1790	0.3990	0.7167	0.3899	0.4363	0.3416	0.8715	0.4635	0.6060	0.7633	0.3302	0.8222
33	0.2769	0.1818	0.6028	0.0155	0.6377	0.5254	0.9283	0.7455	0.7819	0.2902	0.9106	0.3390	0.0474	0.2834	0.5909	0.1739	0.9329	0.3287	0.0093	0.2545	0.8264	0.2297	0.5707
34	0.0462	0.2638	0.7112	0.9841	0.9577	0.5303	0.5801	0.7363	0.1006	0.3175	0.8006	0.2101	0.3424	0.8962	0.4594	0.0261	0.3907	0.6501	0.9150	0.3242	0.5735	0.1139	0.5718
35	0.0971	0.1455	0.2217	0.1672	0.2407	0.8611	0.0170	0.5619	0.2941	0.6537	0.7458	0.5102	0.7360	0.8266	0.0503	0.9547	0.2732	0.9748	0.6427	0.4018	0.7926	0.3109	0.2860
36	0.8235	0.1361	0.1174	0.1062	0.6761	0.4849	0.1209	0.1842	0.2374	0.9569	0.8131	0.9064	0.7947	0.3900	0.2287	0.4306	0.1519	0.0760	0.0014	0.4064	0.3290	0.2284	0.6991
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38	0.3171	0.5797	0.3188	0.1981	0.6718	0.6714	0.4843	0.2999	0.0915	0.4579	0.6173	0.1015	0.6862	0.6948	0.0156	0.7624	0.3747	0.4139	0.2085	0.6098	0.3124	0.0662	0.4416
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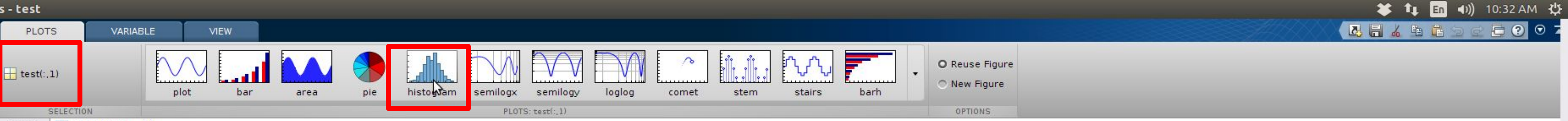
40	0.0344	0.1450	0.5079	0.3395	0.0680	0.5201	0.2094	0.2126	0.1048	0.7639	0.5301	0.0546	0.0548	0.6096	0.0781	0.6800	0.4350	0.2638	0.1273	0.1881	0.8299	0.2818	0.4657
41	0.4387	0.8530	0.0855	0.9516	0.2548	0.3477	0.5523	0.8949	0.1123	0.7593	0.2751	0.5013	0.3037	0.5747	0.6690	0.7060	0.0915	0.7588	0.0086	0.0946	0.2905	0.8801	0.2790
42	0.3816	0.6221	0.2625	0.9203	0.2240	0.1500	0.6299	0.0715	0.7844	0.7406	0.2486	0.4317	0.0462	0.3260	0.5002	0.6451	0.6146	0.9952	0.7271	0.3232	0.4026	0.4443	0.6754



test

100x100 double

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4	0.9134	0.5285	0.5328	0.0714	0.4709	0.2648	0.6967	0.4460	0.1104	0.3968	0.2242	0.8432	0.3531	0.8110	0.5319	0.4294	0.2568	0.0610	0.8803	0.4186	0.1296	0.7203	0.6944
5	0.6324	0.1656	0.3507	0.5216	0.6959	0.3181	0.5828	0.0542	0.1175	0.0740	0.6525	0.9223	0.4494	0.4845	0.2021	0.2573	0.0098	0.5846	0.4711	0.1557	0.2251	0.4840	0.2124
6	0.0975	0.6020	0.9390	0.0967	0.6999	0.1192	0.8154	0.1771	0.6407	0.6841	0.6050	0.7710	0.9635	0.7567	0.4539	0.2976	0.5323	0.2851	0.4040	0.8190	0.3500	0.6390	0.5433
7	0.2785	0.2630	0.8759	0.8181	0.6385	0.9398	0.8790	0.6628	0.3288	0.4024	0.3872	0.0427	0.0423	0.4170	0.4279	0.4249	0.2794	0.8277	0.1792	0.6249	0.2871	0.8876	0.7025
8	0.5469	0.6541	0.5502	0.8175	0.0336	0.6456	0.9889	0.3308	0.6538	0.9828	0.1422	0.3782	0.9730	0.9718	0.9661	0.1192	0.9462	0.1910	0.9689	0.7386	0.9275	0.1987	0.9564
9	0.9575	0.6892	0.6225	0.7224	0.0688	0.4795	5.2238e-...	0.8985	0.7491	0.4022	0.0251	0.7043	0.1892	0.9880	0.6201	0.4951	0.9064	0.4425	0.4075	0.8051	0.0513	0.3954	0.4445
10	0.9649	0.7482	0.5870	0.1499	0.3196	0.6393	0.8654	0.1182	0.5832	0.6207	0.4211	0.7295	0.6671	0.8641	0.6954	0.7064	0.3927	0.3934	0.8445	0.0672	0.5927	0.9922	0.0854
11	0.1576	0.4505	0.2077	0.6596	0.5309	0.5447	0.6126	0.9884	0.7400	0.1544	0.1841	0.2243	0.5864	0.3889	0.7202	0.2436	0.0249	0.8266	0.6153	0.9508	0.1629	0.4024	0.0573
12	0.9706	0.0838	0.3012	0.5186	0.6544	0.6473	0.9900	0.5400	0.2348	0.3813	0.7258	0.2691	0.6751	0.4547	0.3469	0.7851	0.6714	0.6769	0.3766	0.4976	0.8384	0.6589	0.6295
13	0.9572	0.2290	0.4709	0.9730	0.4076	0.5439	0.5277	0.7069	0.7350	0.1611	0.3704	0.6730	0.3610	0.2467	0.5170	0.0741	0.8372	0.2076	0.8772	0.7551	0.1676	0.9013	0.7962
14	0.4854	0.9133	0.2305	0.6490	0.8200	0.7210	0.4795	0.9995	0.9706	0.7581	0.8416	0.4775	0.6203	0.7844	0.5567	0.3939	0.9715	0.3181	0.7849	0.7424	0.5022	0.9954	0.6912
15	0.8003	0.1524	0.8443	0.8003	0.7184	0.5225	0.8013	0.2878	0.8669	0.8711	0.7342	0.6237	0.8112	0.8828	0.1565	0.0034	0.0569	0.1338	0.4650	0.8311	0.9993	0.6532	0.3453
16	0.1419	0.8258	0.1948	0.4538	0.9686	0.9937	0.2278	0.4145	0.0862	0.3508	0.5710	0.2364	0.0193	0.9137	0.5621	0.2207	0.4503	0.6715	0.8140	0.1565	0.3554	0.1084	0.9468
17	0.4218	0.5383	0.2259	0.4324	0.5313	0.2187	0.4981	0.4648	0.3664	0.6855	0.1769	0.1771	0.0839	0.5583	0.6948	0.0013	0.5825	0.5710	0.8984	0.4573	0.0471	0.0361	0.5202
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21	0.6557	0.1067	0.3111	0.1734	0.7788	0.4046	0.7386	0.1781	0.7894	0.5975	0.2238	0.1079	0.4035	0.4504	0.3600	0.1749	0.7269	0.9081	0.9020	0.8954	0.2296	0.7461	0.7750
22	0.0357	0.9619	0.9234	0.3909	0.4235	0.4484	0.5860	0.3596	0.3677	0.3353	0.3736	0.1822	0.1220	0.2057	0.4542	0.1386	0.3738	0.5522	0.7021	0.5825	0.9361	0.6625	0.9142
23	0.8491	0.0046	0.4302	0.8314	0.0908	0.3658	0.2467	0.0567	0.2060	0.2992	0.0875	0.0991	0.2684	0.8997	0.3864	0.5989	0.5816	0.0329	0.3775	0.5827	0.6832	0.5233	0.7826
24	0.9340	0.7749	0.1848	0.8034	0.2665	0.7635	0.6664	0.5219	0.0867	0.4526	0.6401	0.4898	0.2578	0.7626	0.7756	0.9011	0.1161	0.0539	0.7350	0.8549	0.9621	0.2599	0.2955
25	0.6787	0.8173	0.9049	0.0605	0.1537	0.6279	0.0835	0.3358	0.7719	0.4226	0.1806	0.1932	0.3317	0.8825	0.7343	0.9394	0.0577	0.8051	0.9541	0.0349	0.4380	0.9620	0.1518
26	0.7577	0.8687	0.9797	0.3993	0.2810	0.7720	0.6260	0.1757	0.2057	0.3596	0.0451	0.8959	0.1522	0.2850	0.4303	0.2212	0.9798	0.4514	0.5428	0.8854	0.9403	0.5402	0.8479
27	0.7431	0.0844	0.4389	0.5269	0.4401	0.9329	0.6609	0.2089	0.3883	0.5583	0.7232	0.0991	0.3480	0.6732	0.6938	0.4827	0.2848	0.3826	0.5401	0.4077	0.0058	0.0303	0.7849
28	0.3922	0.3998	0.1111	0.4168	0.5271	0.9727	0.7298	0.9052	0.5518	0.7425	0.3474	0.0442	0.1217	0.6643	0.9452	0.3760	0.5950	0.7896	0.3111	0.0364	0.6103	0.6963	0.2708
29	0.6555	0.2599	0.2581	0.6569	0.4574	0.1920	0.8908	0.6754	0.2290	0.4243	0.6606	0.5573	0.8842	0.1228	0.7842	0.5238	0.9622	0.3643	0.0712	0.7461	0.8011	0.5197	0.2278
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31	0.7060	0.4314	0.5949	0.2920	0.5181	0.6963	0.7690	0.9121	0.4845	0.1249	0.6273	0.3119	0.9300	0.2753	0.1093	0.0684	0.1930	0.7117	0.0930	0.1439	0.9325	0.8900	0.8296
32	0.0318	0.9106	0.2622	0.4317	0.9436	0.0938	0.5814	0.1040	0.1518	0.0244	0.0216	0.1790	0.3990	0.7167	0.3899	0.4363	0.3416	0.8715	0.4635	0.6060	0.7633	0.3302	0.8222
33	0.2769	0.1818	0.6028	0.0155	0.6377	0.5254	0.9283	0.7455	0.7819	0.2902	0.9106	0.3390	0.0474	0.2834	0.5909	0.1739	0.9329	0.3287	0.0093	0.2545	0.8264	0.2297	0.5707
34	0.0462	0.2638	0.7112	0.9841	0.9577	0.5303	0.5801	0.7363	0.1006	0.3175	0.8006	0.2101	0.3424	0.8962	0.4594	0.0261	0.3907	0.6501	0.9150	0.3242	0.5735	0.1139	0.5718
35	0.0971	0.1455	0.2217	0.1672	0.2407	0.8611	0.0170	0.5619	0.2941	0.6537	0.7458	0.5102	0.7360	0.8266	0.0503	0.9547	0.2732	0.9748	0.6427	0.4018	0.7926	0.3109	0.2860
36	0.8235	0.1361	0.1174	0.1062	0.6761	0.4849	0.1209	0.1842	0.2374	0.9569	0.8131	0.9064	0.7947	0.3900	0.2287	0.4306	0.1519	0.0760	0.0014	0.4064	0.3290	0.2284	0.6991
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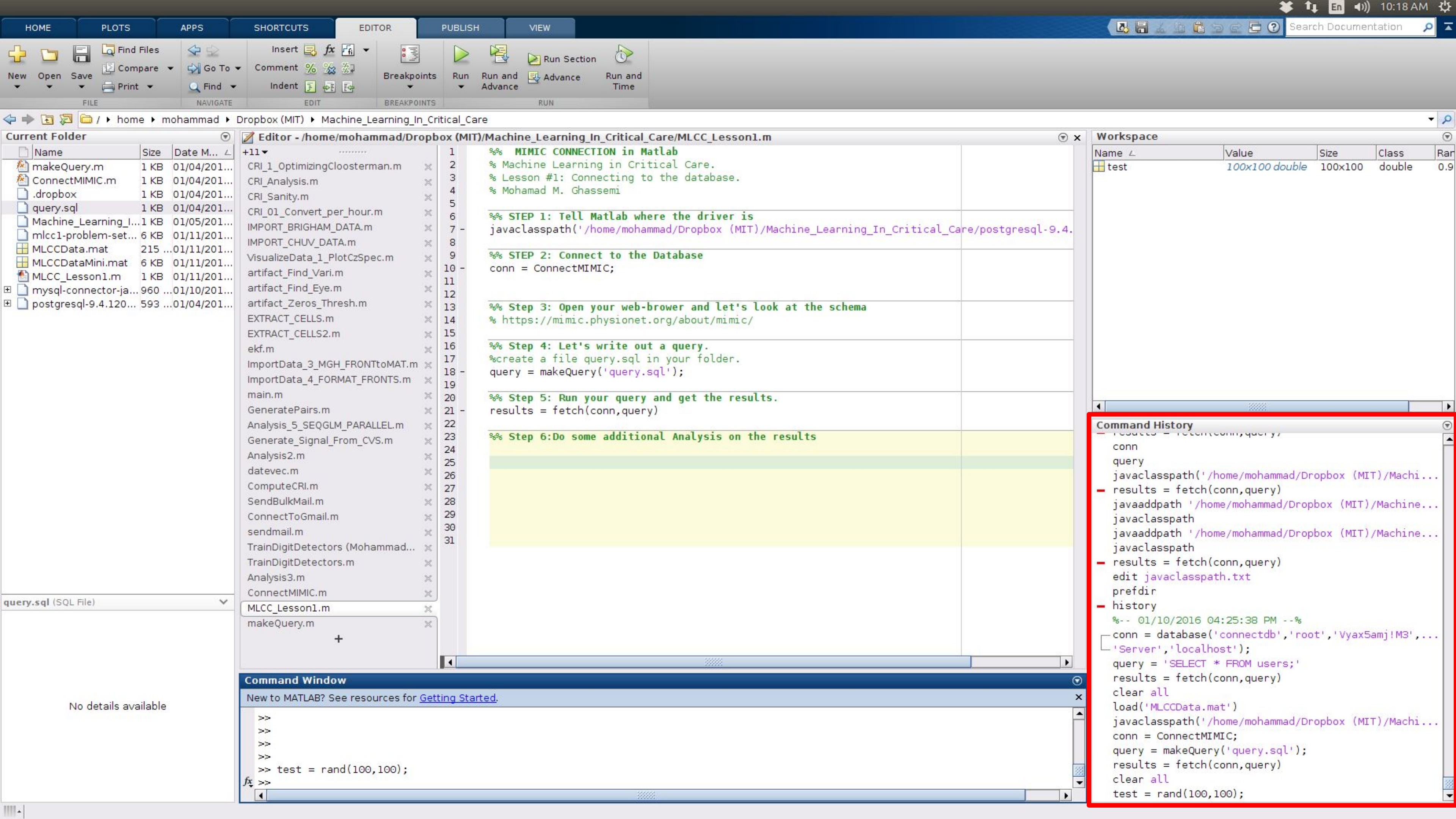
41	0.4387	0.8530	0.0855	0.9516	0.2548	0.3477	0.5523	0.8949	0.1123	0.7593	0.2751	0.5013	0.3037	0.5747	0.6690	0.7060	0.0915	0.7588	0.0086	0.0946	0.2905	0.8801	0.2790
42	0.3816	0.6221	0.2625	0.9203	0.2240	0.1500	0.6299	0.0715	0.7844	0.7406	0.2486	0.4317	0.0462	0.3260	0.5002	0.6451	0.6146	0.9952	0.7271	0.3232	0.4026	0.4443	0.6754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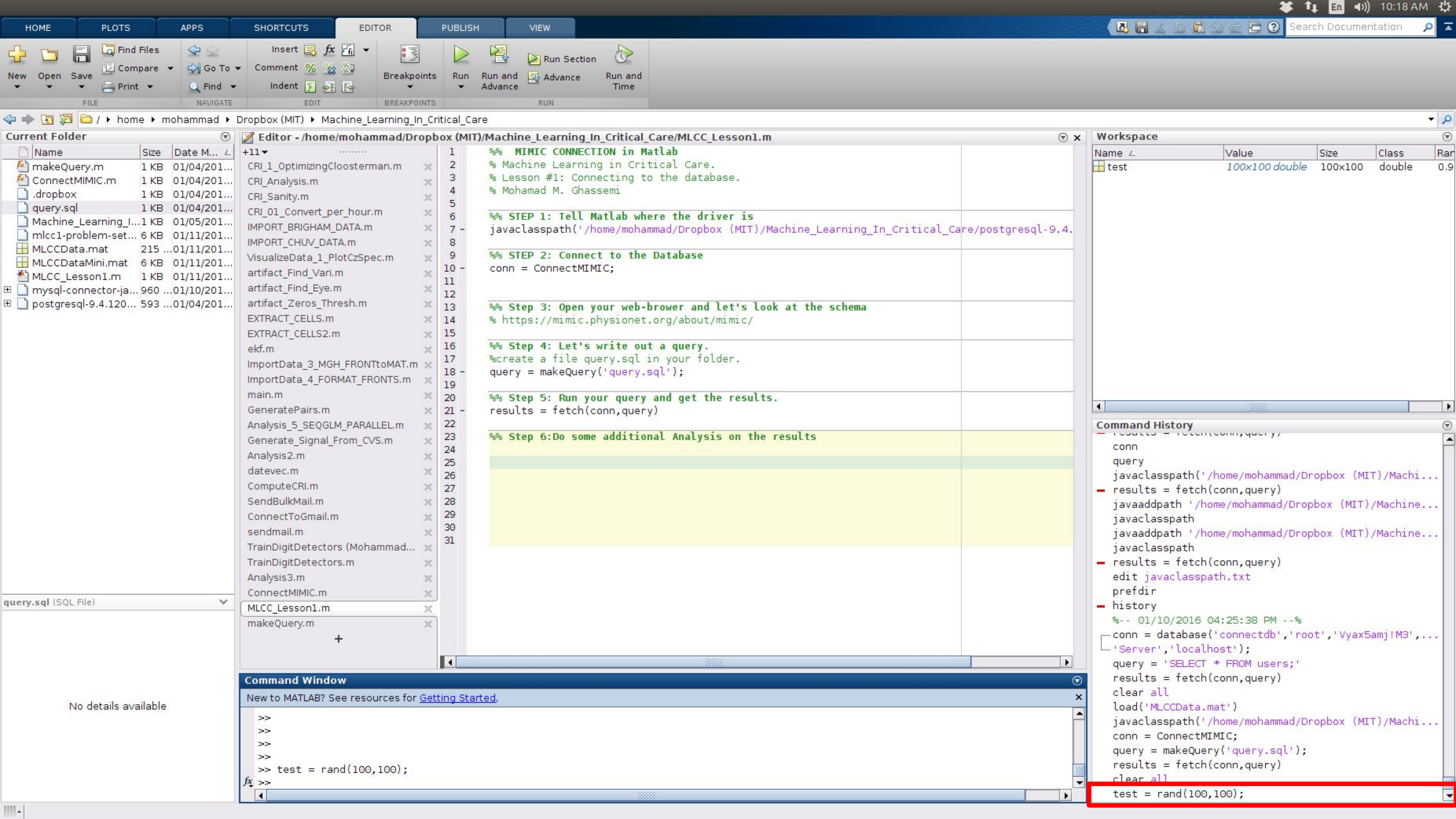
ComputeCRI.m
SendBulkMail.m
ConnectToGmail.m
sendmail.m
TrainDigitDetectors (Mohammad...
TrainDigitDetectors.m
Analysis3.m
ConnectMIMIC.m
MLCC_Lesson1.m
makeQuery.m
%% MIMIC CONNECTION in Matlab
% Machine Learning in Critical Care.
% Lesson #1: Connecting to the database.
% Mohamad M. Ghassemi
%% STEP 1: Tell Matlab where the driver is
javaclasspath('/home/mohammad/Dropbox (MIT)/Machine_Learning_In_Critical_Care/postgresql-9.4.
%% STEP 2: Connect to the Database
conn = ConnectMIMIC;
%% Step 3: Open your web-brower and let's look at the schema
% https://mimic.physionet.org/about/mimic/
%% Step 4: Let's write out a query.
%create a file query.sql in your folder.
query = makeQuery('query.sql');
%% Step 5: Run your query and get the results.
results = fetch(conn,query)
%% Step 6:Do some additional Analysis on the results
Command Window
New to MATLAB? See resources for Getting Started.
>> test = rand(100,100);
Workspace
Name
Value
Size
Class
test
100x100 double
100x100
double
Command History
conn
query
javaclasspath('/home/mohammad/Dropbox (MIT)/Machi...
results = fetch(conn,query)
javaaddpath '/home/mohammad/Dropbox (MIT)/Machine...
javaclasspath
javaaddpath '/home/mohammad/Dropbox (MIT)/Machine...
javaclasspath
results = fetch(conn,query)
edit javaclasspath.txt
prefdir
history
%-- 01/10/2016 04:25:38 PM --%
conn = database('connectdb','root','Vyax5amj!M3',...
'Server','localhost');
query = 'SELECT * FROM users;'
results = fetch(conn,query)
clear all
load('MLCCData.mat')
javaclasspath('/home/mohammad/Dropbox (MIT)/Machi...
conn = ConnectMIMIC;
query = makeQuery('query.sql');
results = fetch(conn,query)
clear all
test = rand(100,100);


HOME
PLOTS
APPS
SHORTCUTS
EDITOR
PUBLISH
VIEW
Search Documentation
New
Open
Save
Find Files
Compare
Print
FILE
Go To
Find
NAVIGATE
Insert
Comment
Indent
EDIT
Breakpoints
BREAKPOINTS
Run
Run and Advance
Run Section
Advance
Run and Time
RUN
/ home mohammad Dropbox (MIT) Machine_Learning_In_Critical_Care
Current Folder
Name
Size
Date M...
makeQuery.m 1 KB 01/04/201...
ConnectMIMIC.m 1 KB 01/04/201...
.dropbox 1 KB 01/04/201...
query.sql 1 KB 01/04/201...
Machine_Learning_I... 1 KB 01/05/201...
mlcc1-problem-set... 6 KB 01/11/201...
MLCCData.mat 215 ... 01/11/201...
MLCCDataMini.mat 6 KB 01/11/201...
MLCC_Lesson1.m 1 KB 01/11/201...
mysql-connector-ja... 960 ... 01/10/201...
postgresql-9.4.120... 593 ... 01/04/201...
query.sql (SQL File)
No details available
Editor - /home/mohammad/Dropbox (MIT)/Machine_Learning_In_Critical_Care/MLCC_Lesson1.m
+11
CRI_1_OptimizingCloosterman.m
CRI_Analysis.m
CRI_Sanity.m
CRI_01_Convert_per_hour.m
IMPORT_BRIGHAM_DATA.m
IMPORT_CHUV_DATA.m
VisualizeData_1_PlotCzSpec.m
artifact_Find_Vari.m
artifact_Find_Eye.m
artifact_Zeros_Thresh.m
EXTRACT_CELLS.m
EXTRACT_CELLS2.m
ekf.m
ImportData_3_MGH_FRONTtoMAT.m
ImportData_4_FORMAT_FRONTS.m
main.m
GeneratePairs.m
Analysis_5_SEQGLM_PARALLEL.m
Generate_Signal_From_CVS.m
Analysis2.m
datevec.m
ComputeCRI.m
SendBulkMail.m
ConnectToGmail.m
sendmail.m
TrainDigitDetectors (Mohammad...
TrainDigitDetectors.m
Analysis3.m
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MLCC_Lesson1.m
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%% Step 4: Let's write out a query.
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%% Step 6:Do some additional Analysis on the results
Command Window
New to MATLAB? See resources for Getting Started.
>>
>>
>>
>>
>> test = rand(100,100);
>>
Workspace
Name
Value
Size
Class
test 100x100 double 100x100 double 0.9
Command History
conn
query
javaclasspath('/home/mohammad/Dropbox (MIT)/Machi...
results = fetch(conn,query)
javaaddpath '/home/mohammad/Dropbox (MIT)/Machine...
javaclasspath
javaaddpath '/home/mohammad/Dropbox (MIT)/Machine...
javaclasspath
results = fetch(conn,query)
edit javaclasspath.txt
prefdir
history
%-- 01/10/2016 04:25:38 PM --%
conn = database('connectdb','root','Vyax5amj!M3',...
'Server','localhost');
query = 'SELECT * FROM users;'
results = fetch(conn,query)
clear all
load('MLCCData.mat')
javaclasspath('/home/mohammad/Dropbox (MIT)/Machi...
conn = ConnectMIMIC;
query = makeQuery('query.sql');
results = fetch(conn,query)
test = rand(100,100);

The Human Learning Task

To the MatMobile

The Human Learning Task

- I want all of you to forget everything you ever learned about machine learning, and treat mortality prediction as a ***human learning*** task.
- Jim had a cardiac arrest, and is currently on life support. Nobody knows if Jim will wake up from his coma, and taking care of him is very expensive ~20K/day.
- Your boss wants you to generate a procedure to predict Jim's outcome.

The Human Learning Task

- We are going to design an algorithm together to predict the outcomes of the patients by visual inspection alone.

- We want to figure out ***which features*** we extracted are predictive of outcome, and ***how to choose thresholds for their values***.

To the MatMobile

```
%% STEP 1: Let's load the data.
```

Code will be referenced

Load the Data

```
%% STEP 1: Let's load the data.
% you can also do this in the GUI by double clicking the '.mat' file
% on the left hand side panel. Or you can run...
load('MLCCData.mat');
```

```
%% STEP 2: Let's Unpack the Data
for i = 1:size(data,2)
    name = header{i};
    eval([name '= data(:,i);'])
end
```

Load the Data

```
%% STEP 1: Let's load the data.
% you can also do this in the GUI by double clicking the '.mat' file
% on the left hand side panel. Or you can run...
load('MLCCData.mat');
```

```
%% STEP 2: Let's Unpack the Data
for i = 1:size(data,2)
    name = header{i};
    eval([name '= data(:,i);'])
end
```

NOW LOOK AT YOUR WORKSPACE!

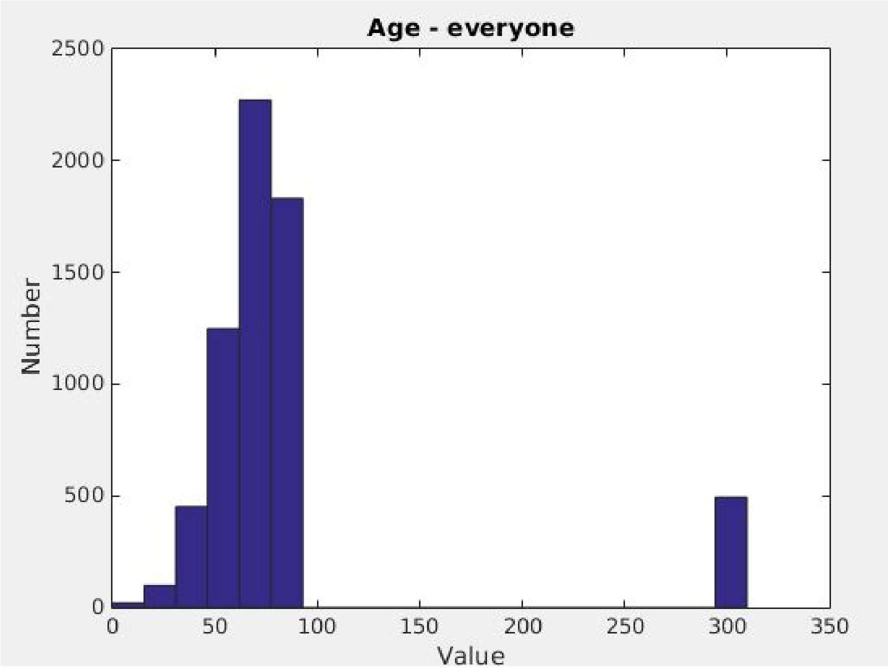
We want to find features that predict outcome

```
'ICUSTAYID'
'OUTCOME'
'Age'
'HeartRateMin'
'HeartRateMax'
'MeanBPMin'
'MeanBPMax'
'RespRateMin'
'RespRateMax'
'GCSMin'
'GCSMax'
'BILIRUBINmin'
'BILIRUBINmax'
'CREATININEmin
'CREATININEmax
'HEMOGLOBINmin
'HEMOGLOBINmax
'SODIUMmin'
'SODIUMmax'
'WBCmin'
'WBCmax'
```

A Black Box
(Literally)

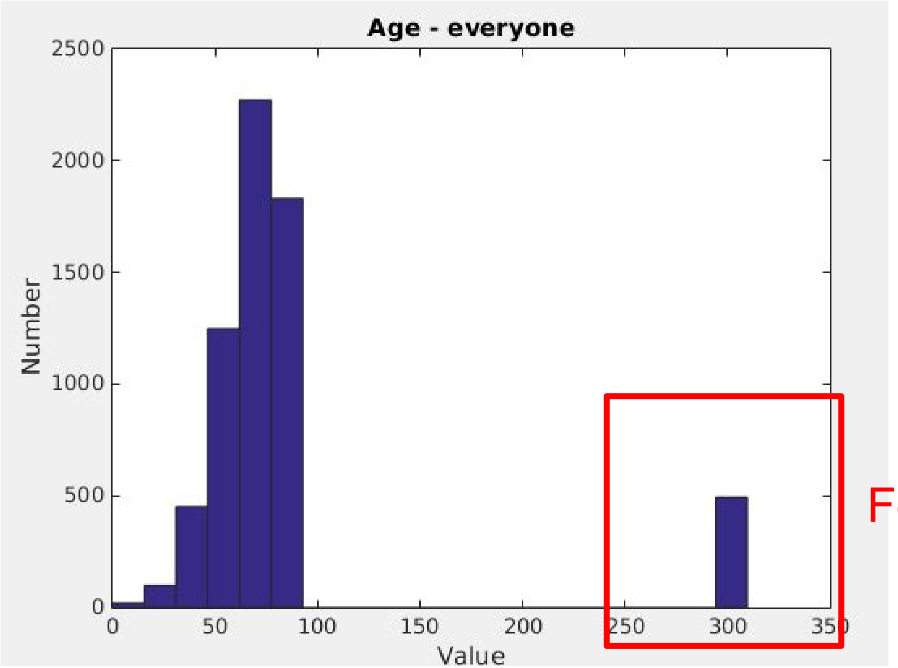
```
%% STEP 3: Let's Visualize some features, starting with Age
```

Let’s Look at Age



```
%% STEP 3: Let's Visualize some features, starting with Age
```

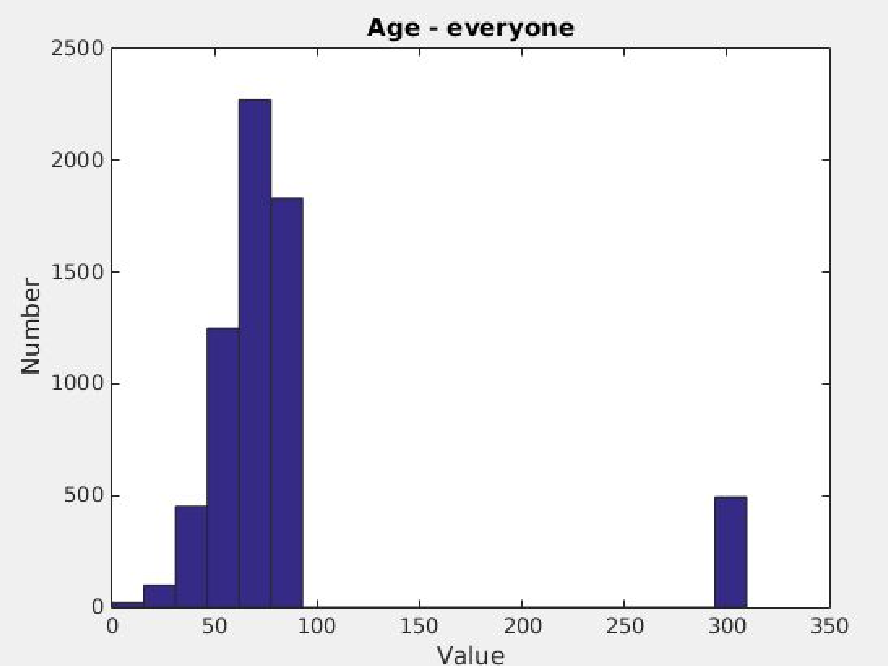
Strange Outliers



Fountain of Youth?!

%% STEP 3: Let's Visualize some features, starting with Age

Outliers exist to protect identity of older patients

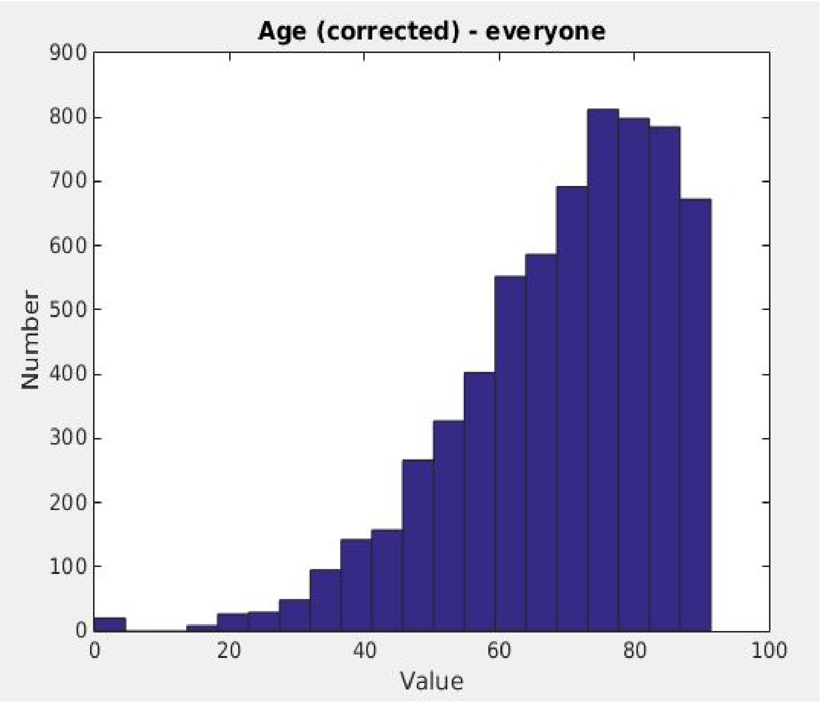


- DOB has been shifted for patients older than 89. The median age for the patients whose date of birth was shifted is 91.4.

https://mimic.physionet.org/mimictables/patients/

```
%% STEP 4: Replace the patients with artificial age values, and plot again!
```

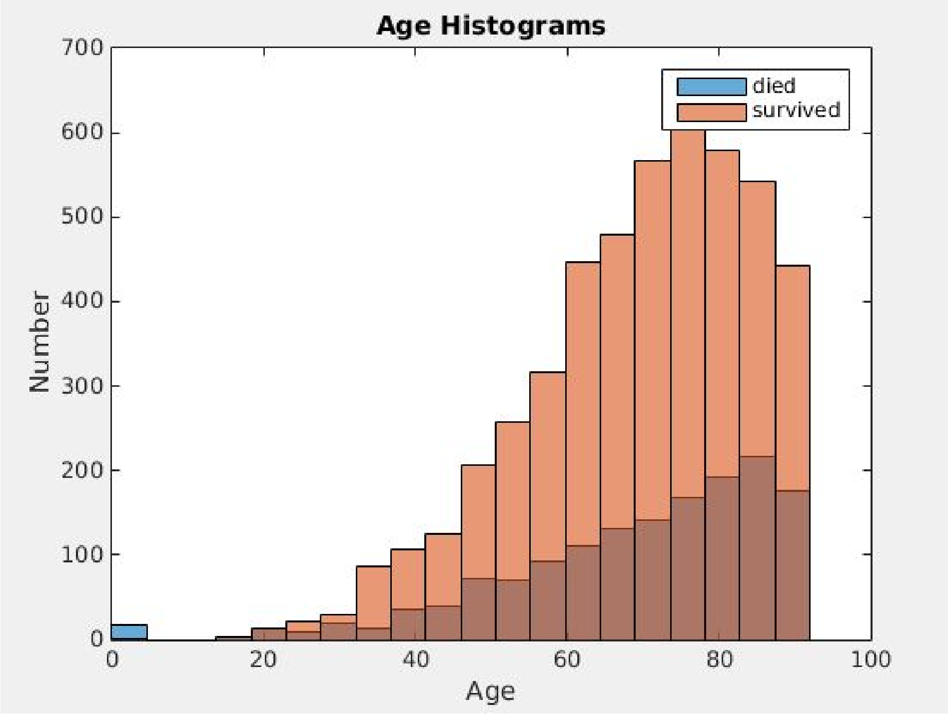
Corrected, the distributions of ages make sense

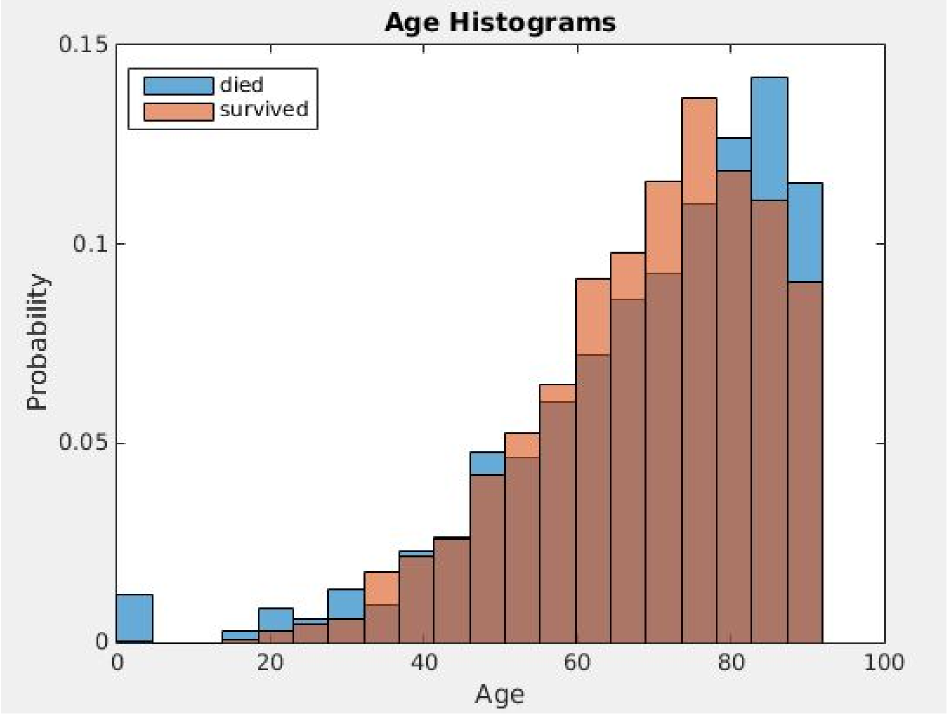


- Much Better!

```
%% STEP 5: Compare Age of patients that survived, versus non-survived
```

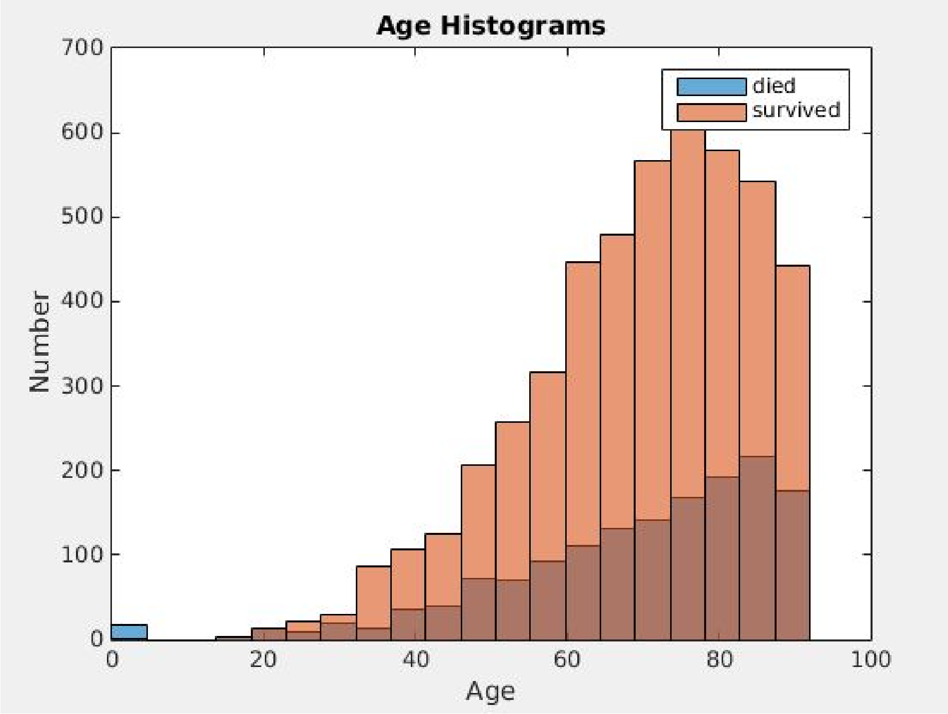
Compare histograms of each outcome class

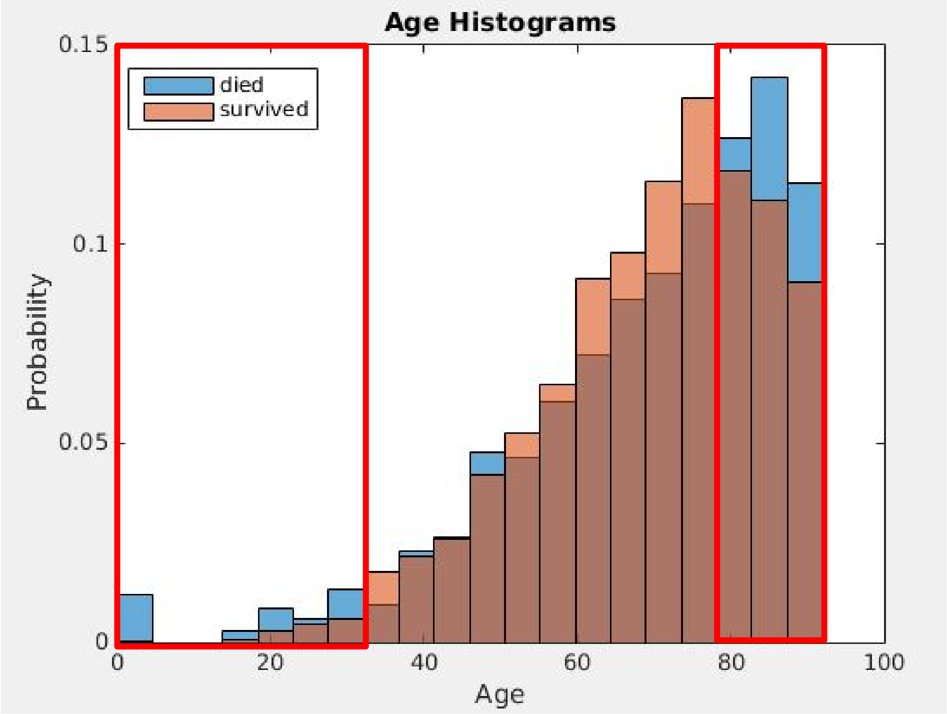




```
%% STEP 5: Compare Age of patients that survived, versus non-survived
```

Survival is more likely when 30 < Age < 75





```
%% STEP 6: The Ageist Algorithm
```

What features should be considered…?

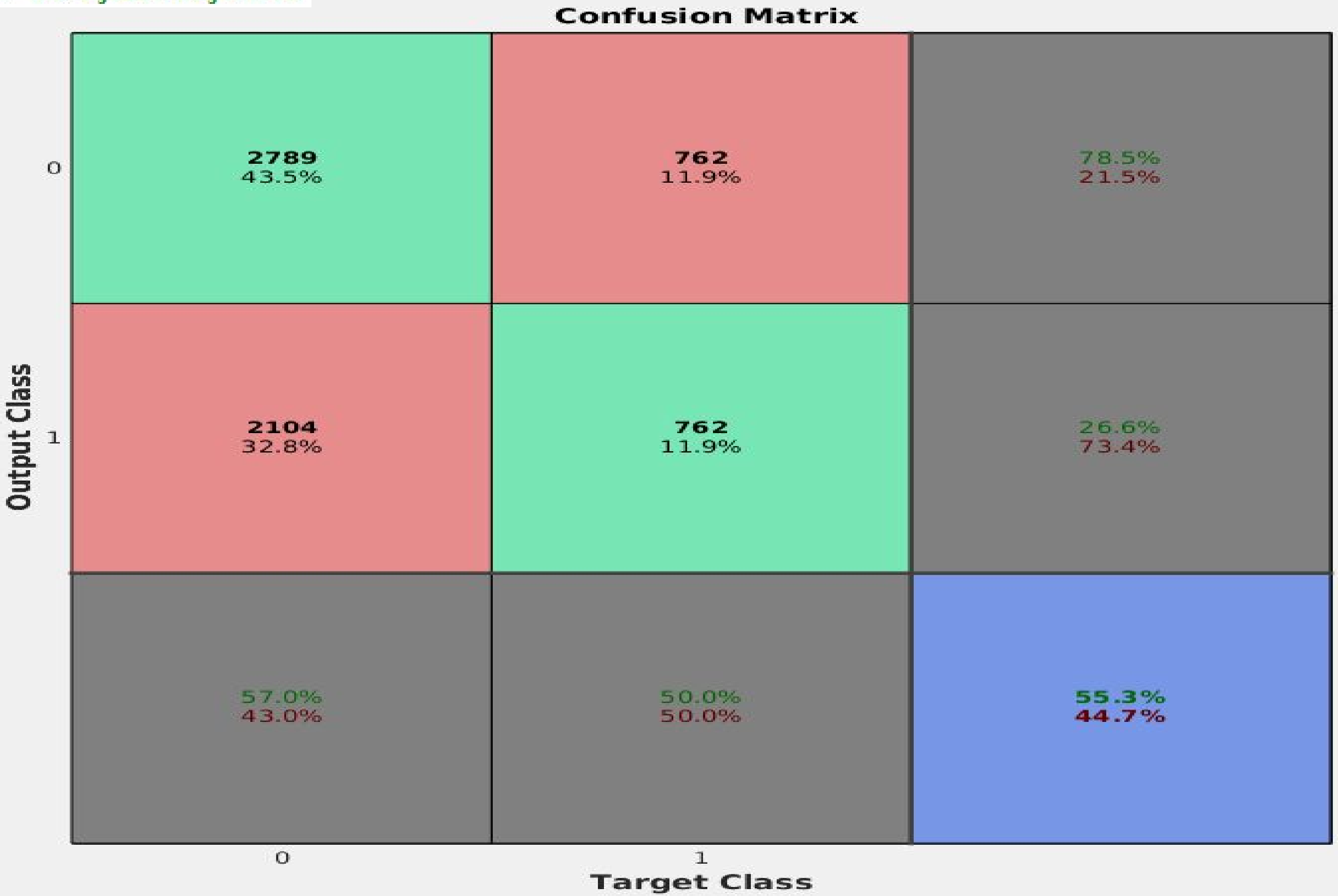
```
'ICUSTAYID'
'OUTCOME'
'Age'
'HeartRateMin'
'HeartRateMax'
'MeanBPMin'
'MeanBPMax'
'RespRateMin'
'RespRateMax'
'GCSMin'
'GCSMax'
'BILIRUBINmin'
'BILIRUBINmax'
'CREATININEmin
'CREATININEmax
'HEMOGLOBINmin
'HEMOGLOBINmax
'SODIUMmin'
'SODIUMmax'
'WBCmin'
'WBCmax'
```

A Black Box
(Literally)

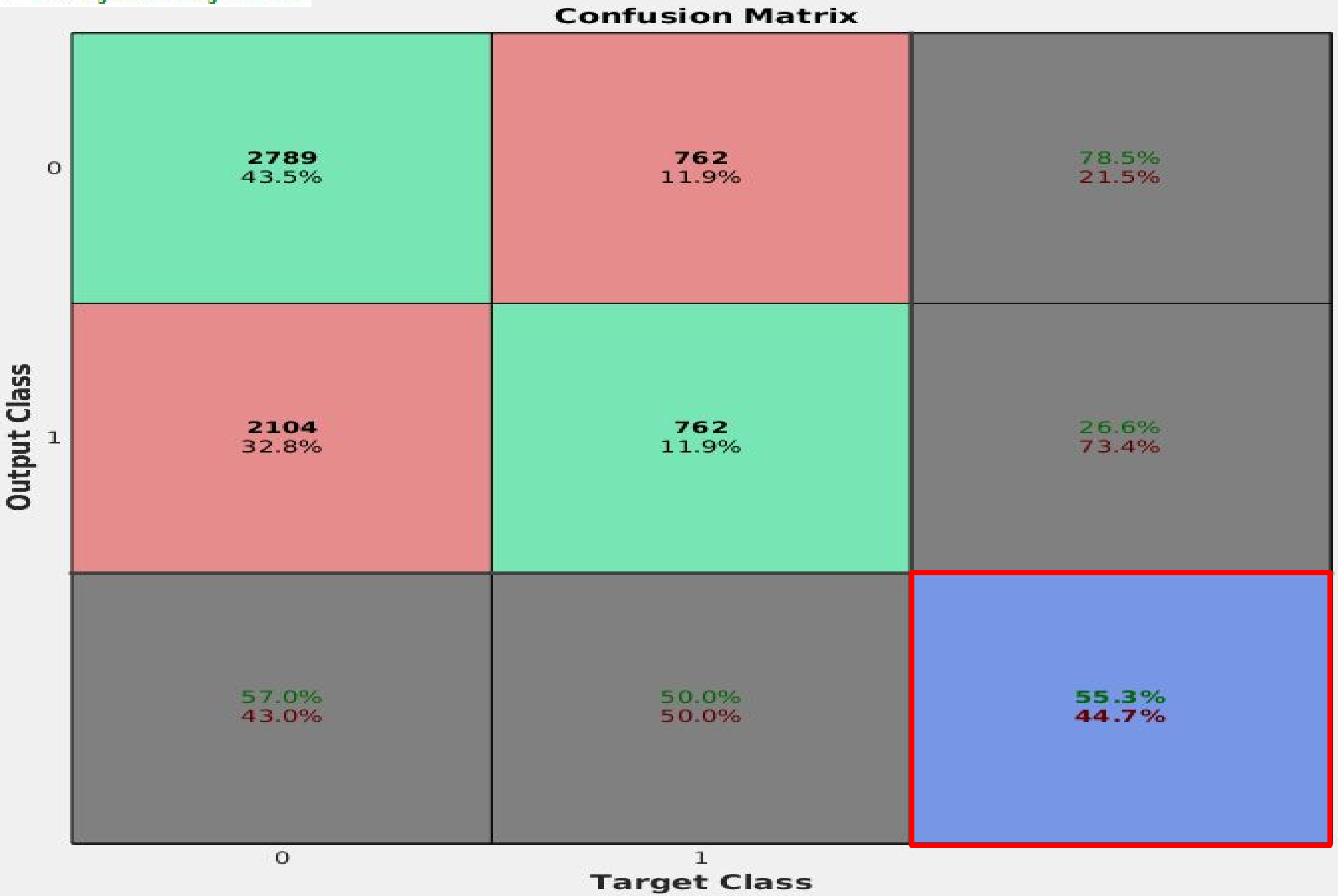
Inside The Box

prediction = death if
(Age < 30 | Age > 75)

%% STEP 6: The Ageist Algorithm

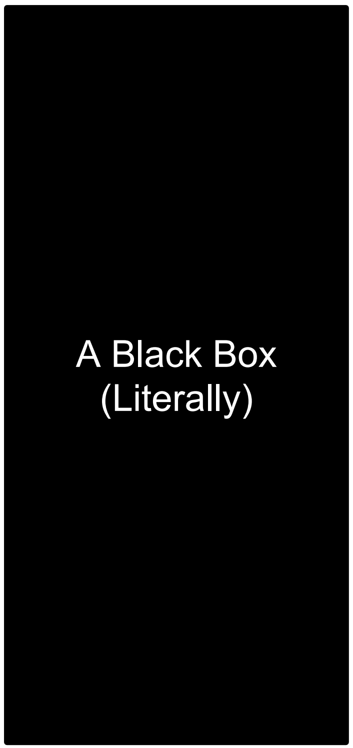


%% STEP 6: The Ageist Algorithm



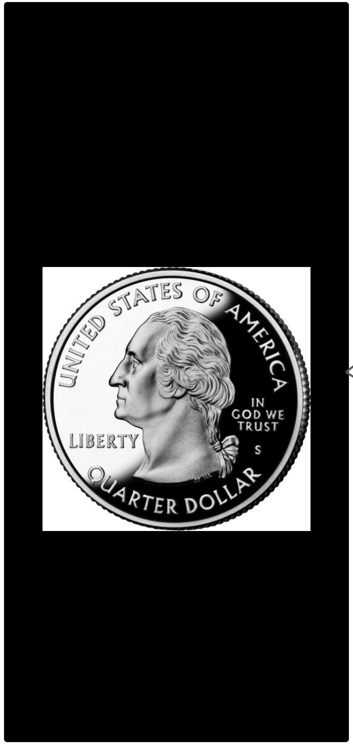
What features should be considered...?

'ICUSTAYID'
'OUTCOME'
'Age'
'HeartRateMin'
'HeartRateMax'
'MeanBPMin'
'MeanBPMax'
'RespRateMin'
'RespRateMax'
'GCSMin'
'GCSMax'
'BILIRUBINmin'
'BILIRUBINmax'
'CREATININEmin
'CREATININEmax
'HEMOGLOBINmin
'HEMOGLOBINmax
'SODIUMmin'
'SODIUMmax'
'WBCmin'
'WBCmax'



What features should be considered…?

'ICUSTAYID'
'OUTCOME'
'Age'
'HeartRateMin'
'HeartRateMax'
'MeanBPMin'
'MeanBPMax'
'RespRateMin'
'RespRateMax'
'GCSMin'
'GCSMax'
'BILIRUBINmin'
'BILIRUBINmax'
'CREATININEmin'
'CREATININEmax'
'HEMOGLOBINmin'
'HEMOGLOBINmax'
'SODIUMmin'
'SODIUMmax'
'WBCmin'
'WBCmax'

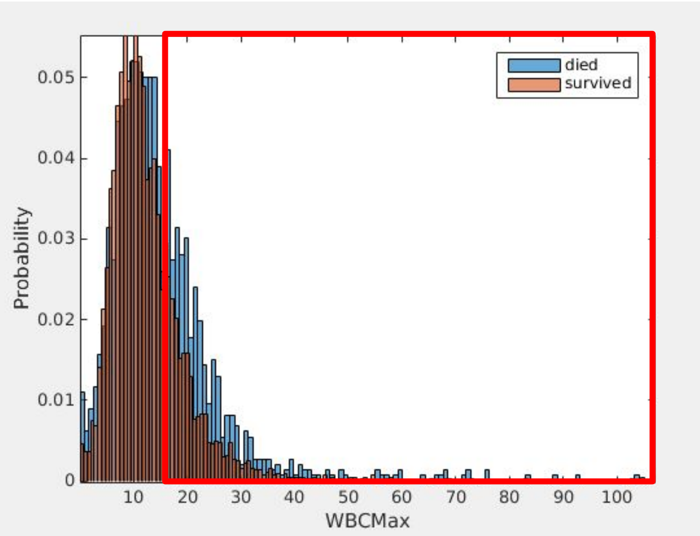


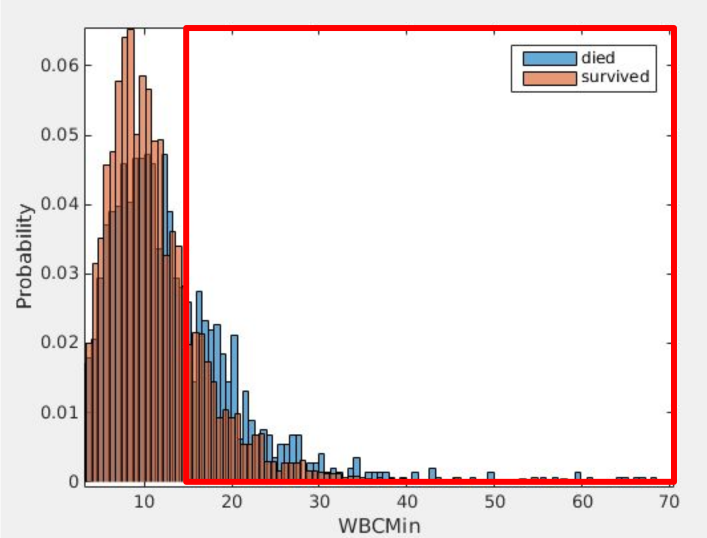
Lived!

Died!

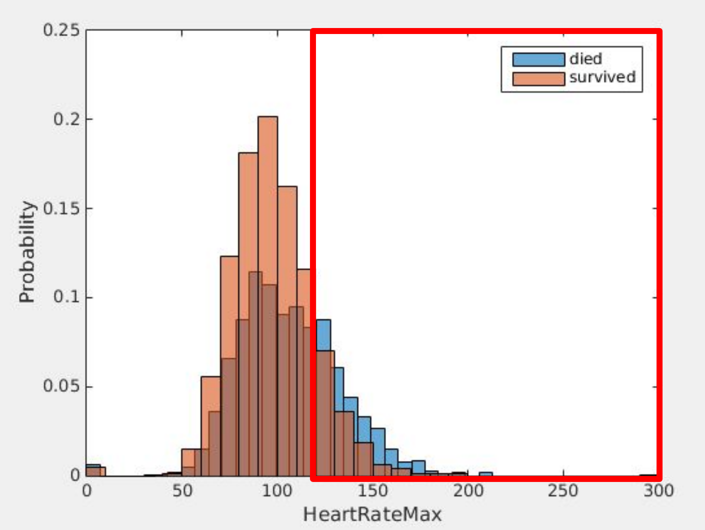
We can do better!

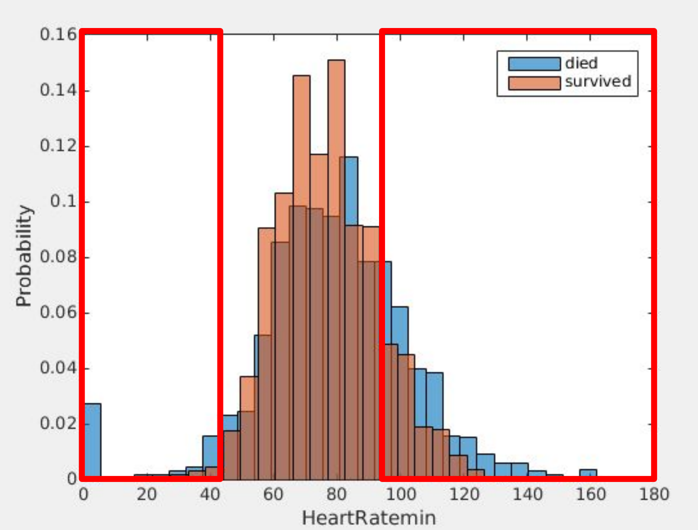
%% STEP 7: More Features





Interesting patterns exist for other features





What would the histograms of a perfect feature look like?

```
%% STEP 8: The Better Black Box
```

Let’s Make a Better Black Box

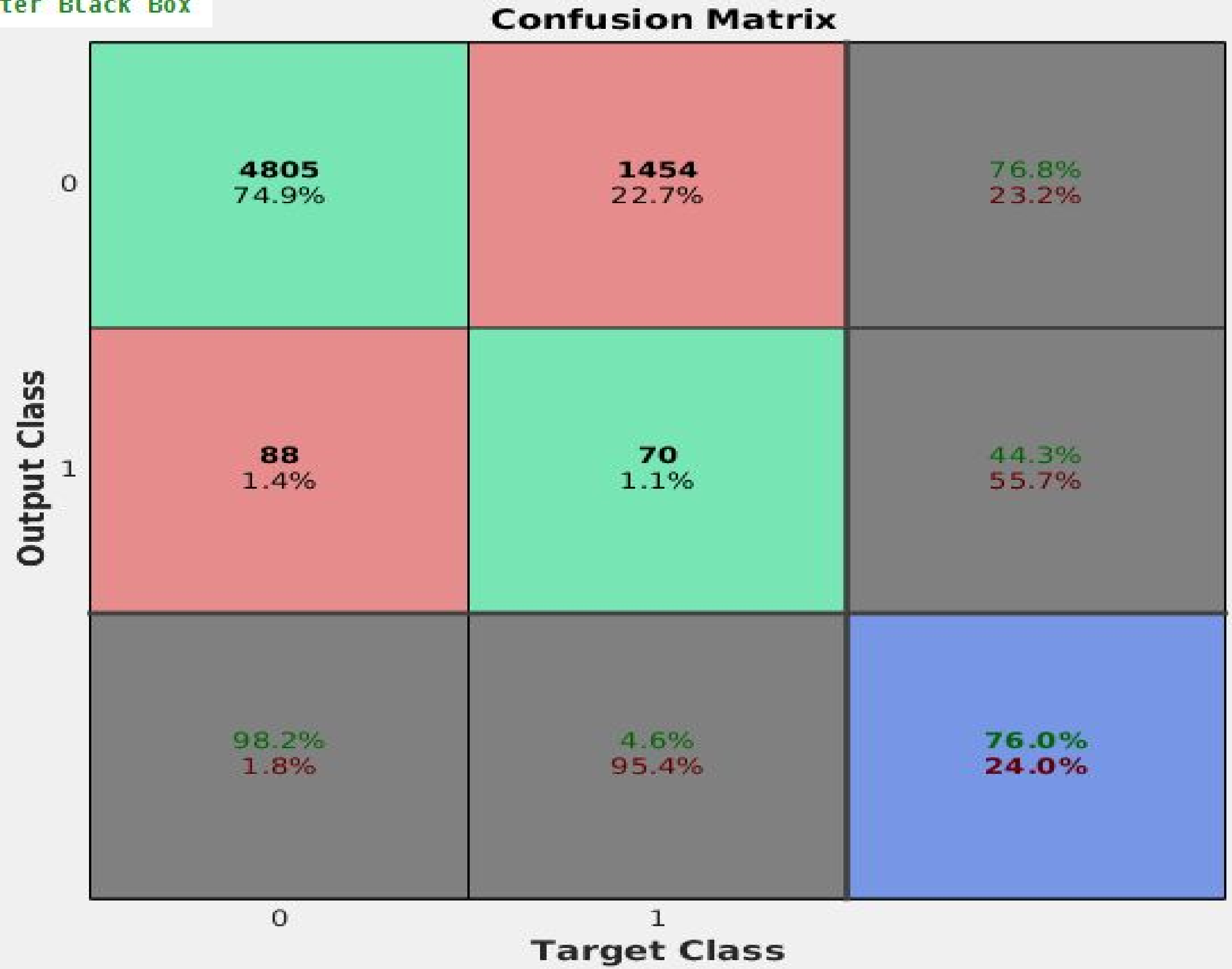
```
'ICUSTAYID'
'OUTCOME'
'Age'
'HeartRateMin'
'HeartRateMax'
'MeanBPMin'
'MeanBPMax'
'RespRateMin'
'RespRateMax'
'GCSMin'
'GCSMax'
'BILIRUBINmin'
'BILIRUBINmax'
'CREATININEmin
'CREATININEmax
'HEMOGLOBINmin
'HEMOGLOBINmax
'SODIUMmin'
'SODIUMmax'
'WBCmin'
'WBCmax'
```

A Better Black Box
(Literally)

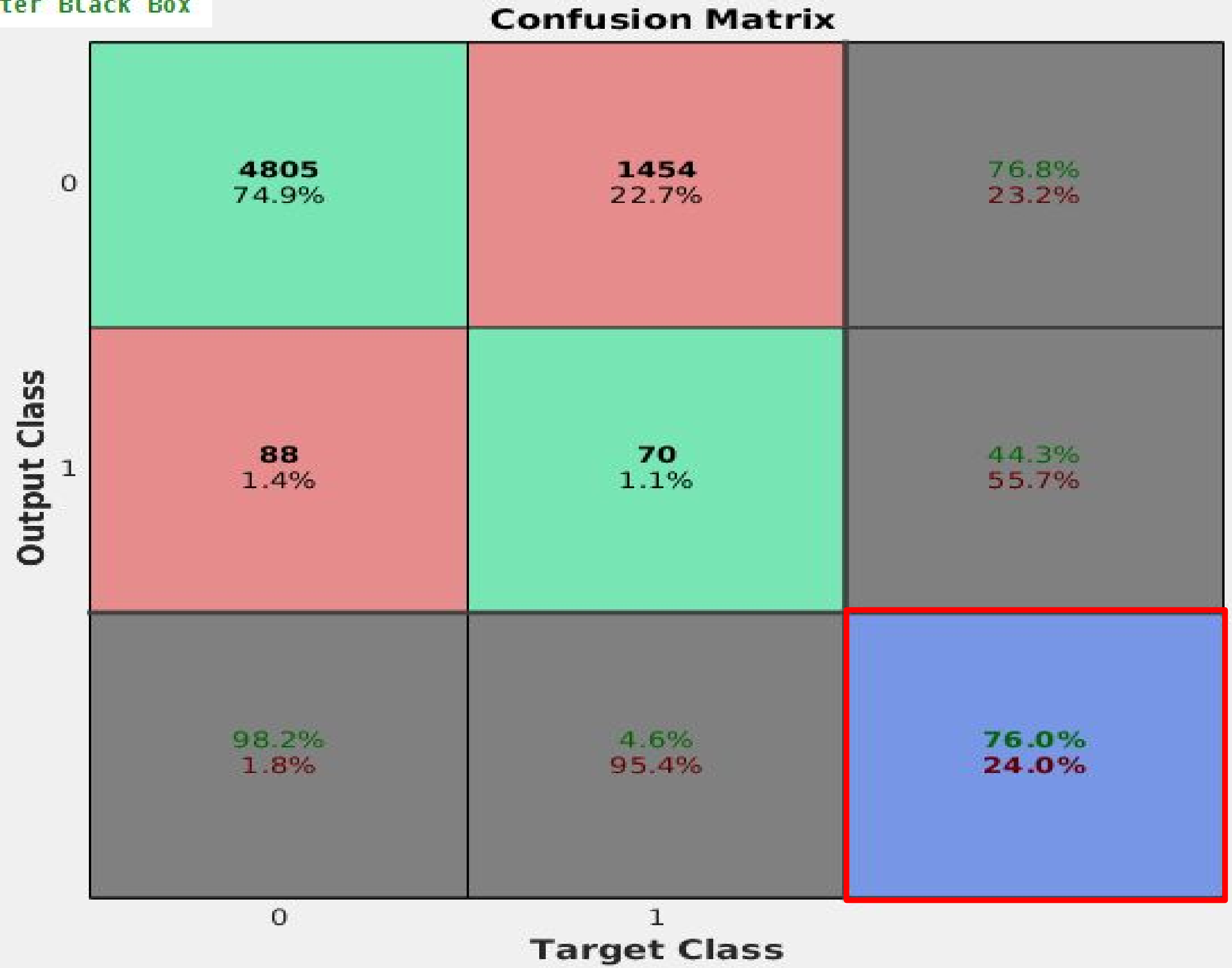
Inside The Better Black Box

prediction = death if
WBCmax > 15 &
WBCmin > 15 &
HeartRateMin > 100

%% STEP 8: The Better Black Box



```
%% STEP 8: The Better Black Box
```



Victory!

Or is it…?

```
%% STEP 9: The Optimist's Algorithm
```

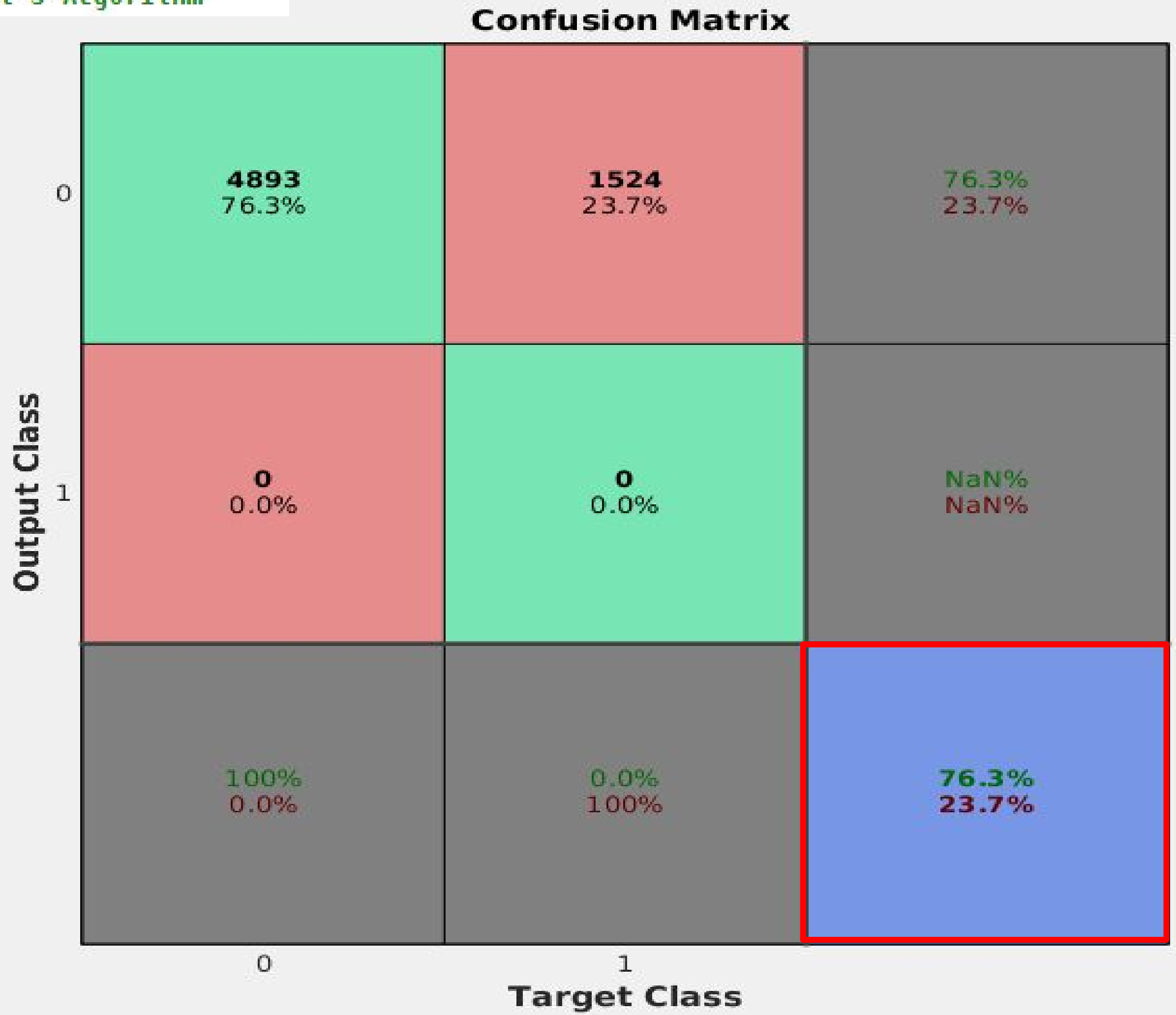
Let’s Try The Optimist’s Algorithm

```
'ICUSTAYID'
'OUTCOME'
'Age'
'HeartRateMin'
'HeartRateMax'
'MeanBPMin'
'MeanBPMax'
'RespRateMin'
'RespRateMax'
'GCSMin'
'GCSMax'
'BILIRUBINmin'
'BILIRUBINmax'
'CREATININEmin
'CREATININEmax
'HEMOGLOBINmin
'HEMOGLOBINmax
'SODIUMmin'
'SODIUMmax'
'WBCmin'
'WBCmax'
```

A Better Black Box
(Literally)

Everyone Always Survives!

%% STEP 9: The Optimist's Algorithm



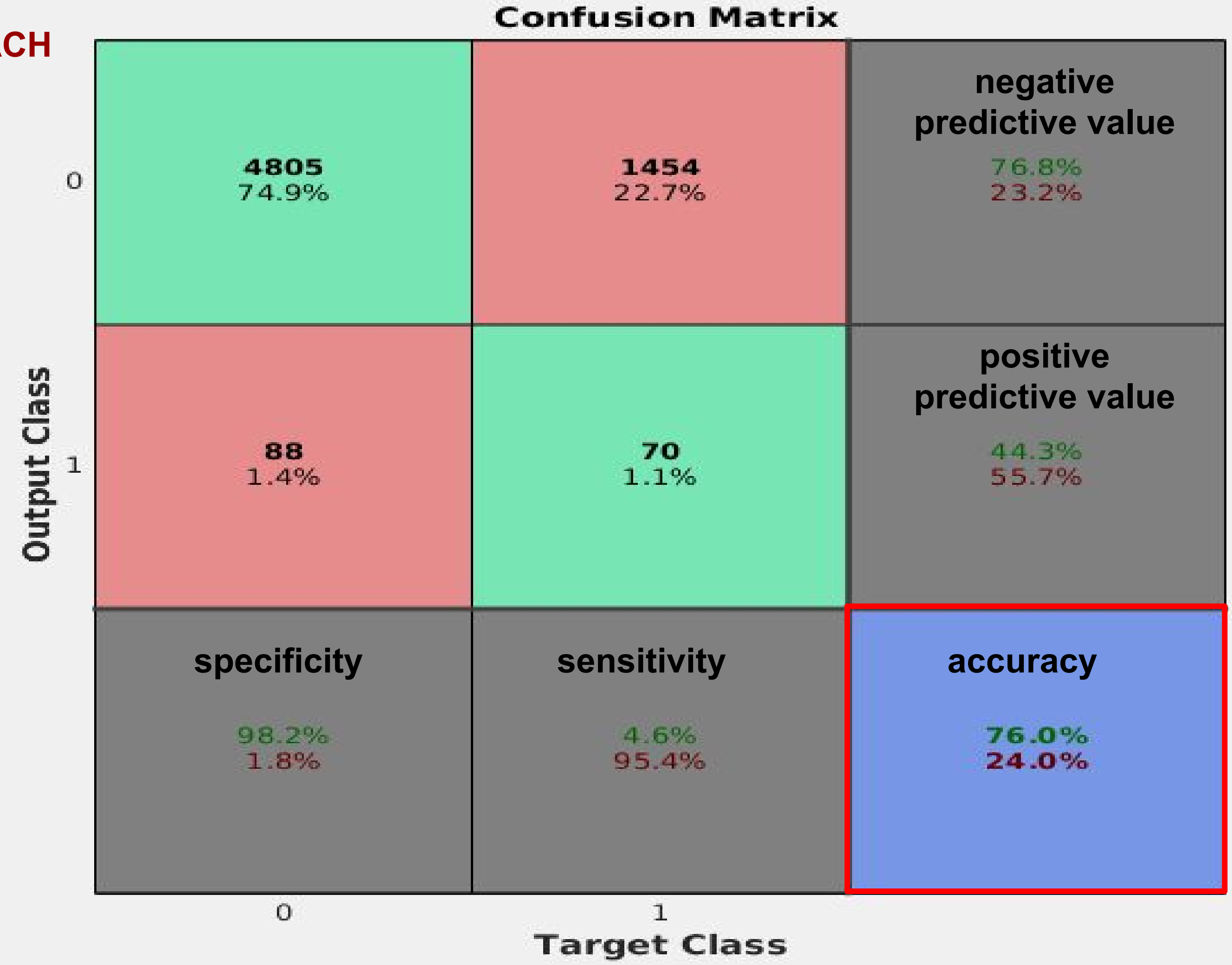
Oh dear...
0.3% better...


Choose
Optimism.

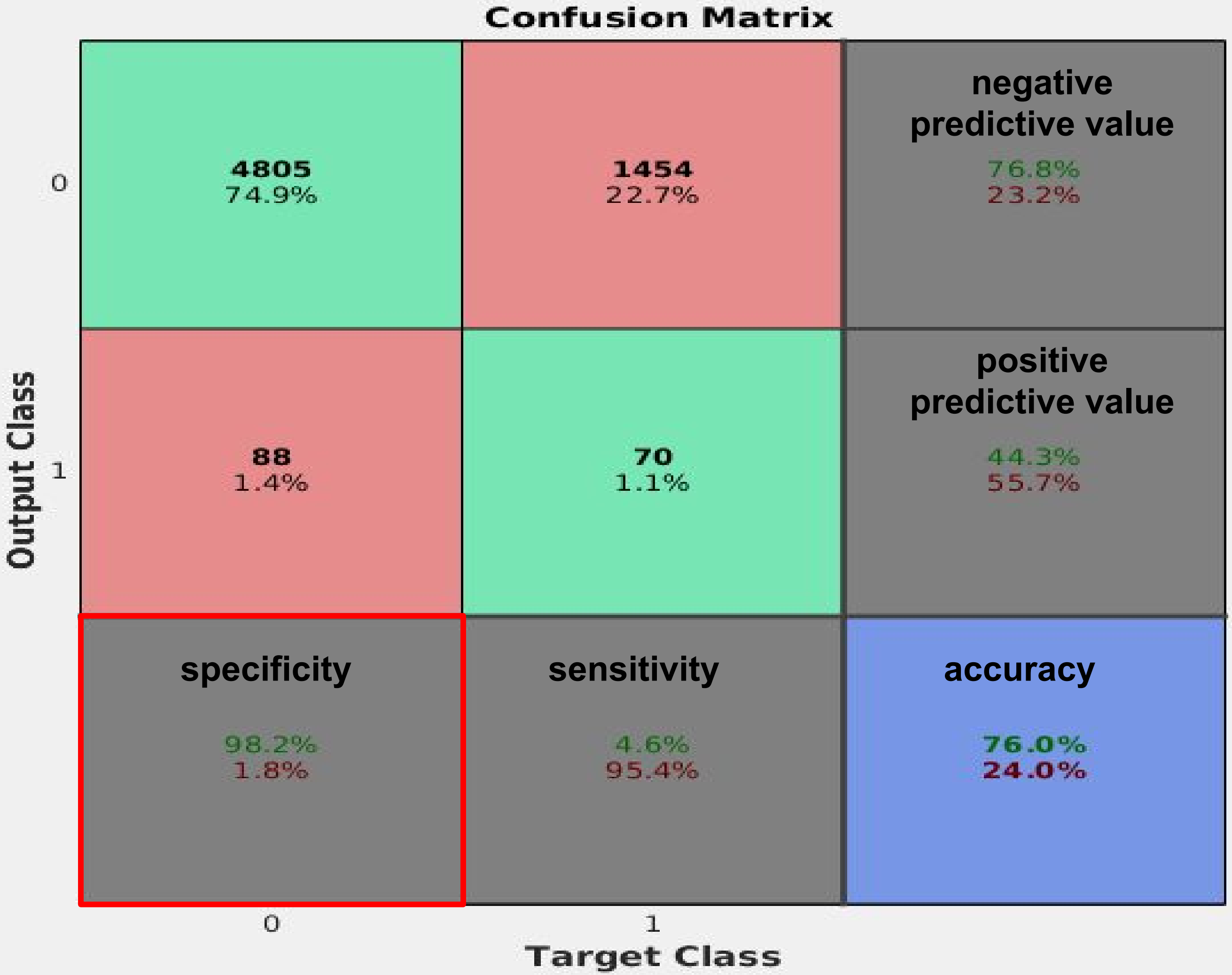

Choose
Optimism.

Why is this happening?

OUR APPROACH



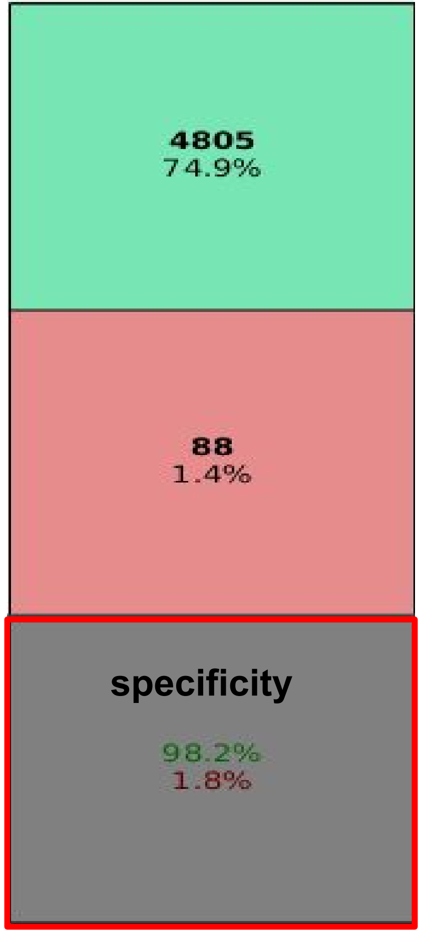
Accuracy may not be a good measure of performance when you have uneven class sizes.

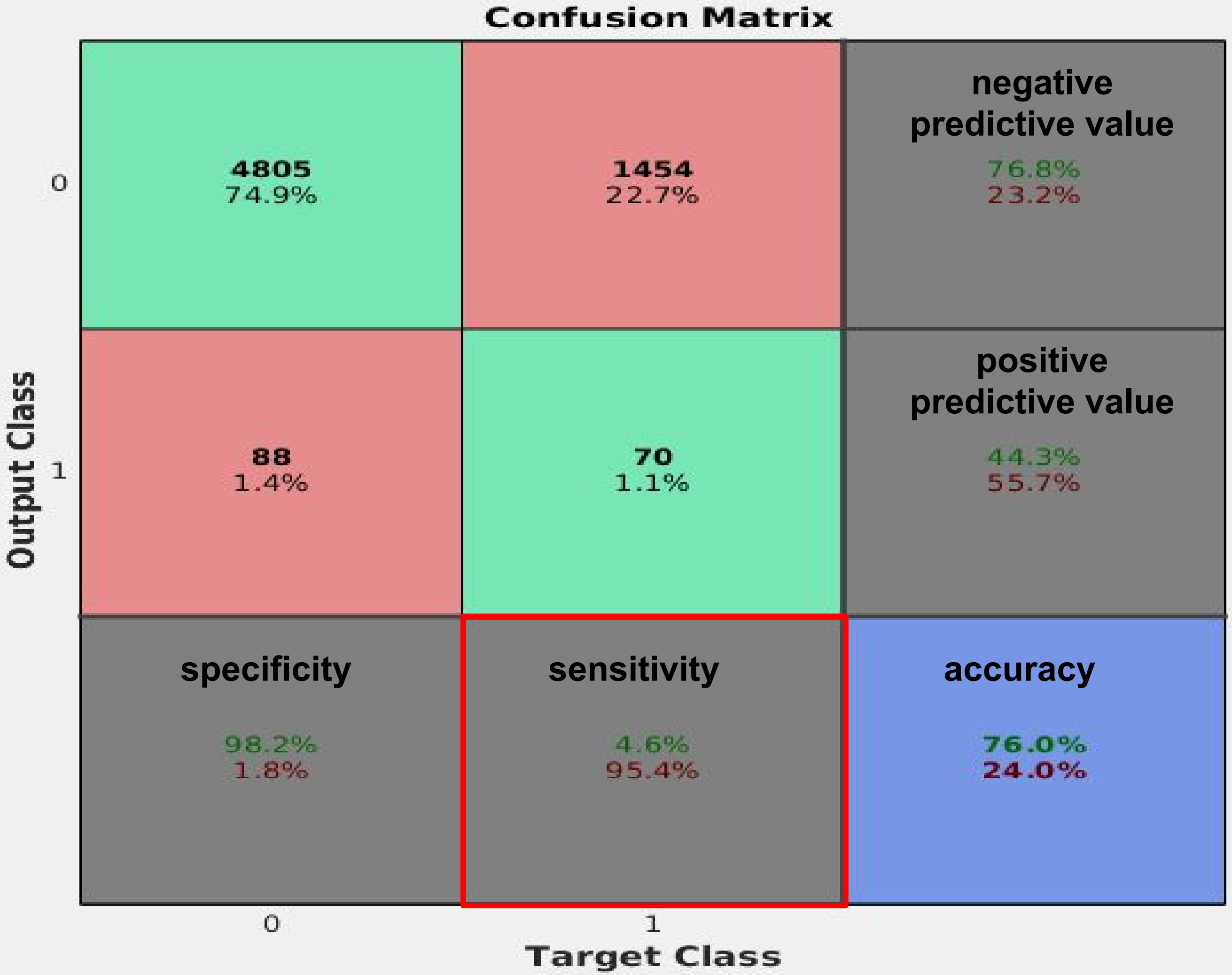

Confusion Matrix
Output Class
0
1
4805
74.9%
1454
22.7%
negative
predictive value
76.8%
23.2%
88
1.4%
70
1.1%
positive
predictive value
44.3%
55.7%
specificity
98.2%
1.8%
sensitivity
4.6%
95.4%
accuracy
76.0%
24.0%
0
1
Target Class

Specificity

- *Specificity= true survivors/(true survivors + false deaths)*

- Given that a person is going to survive, how often will the test indicate survival?



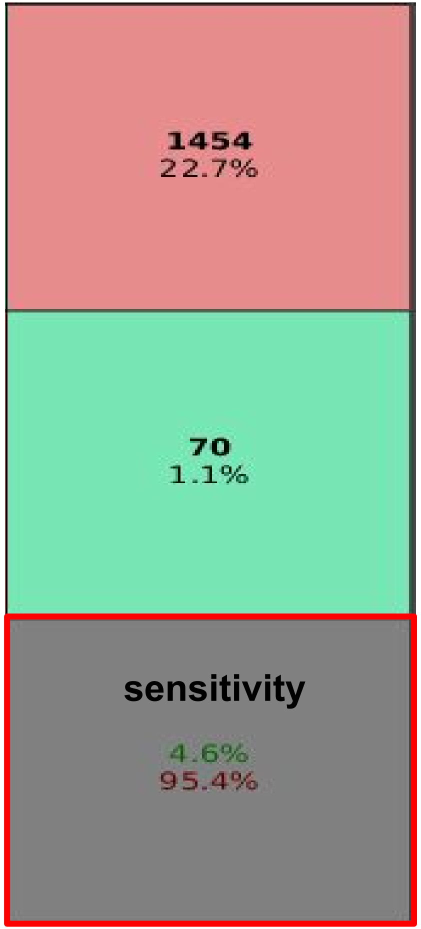


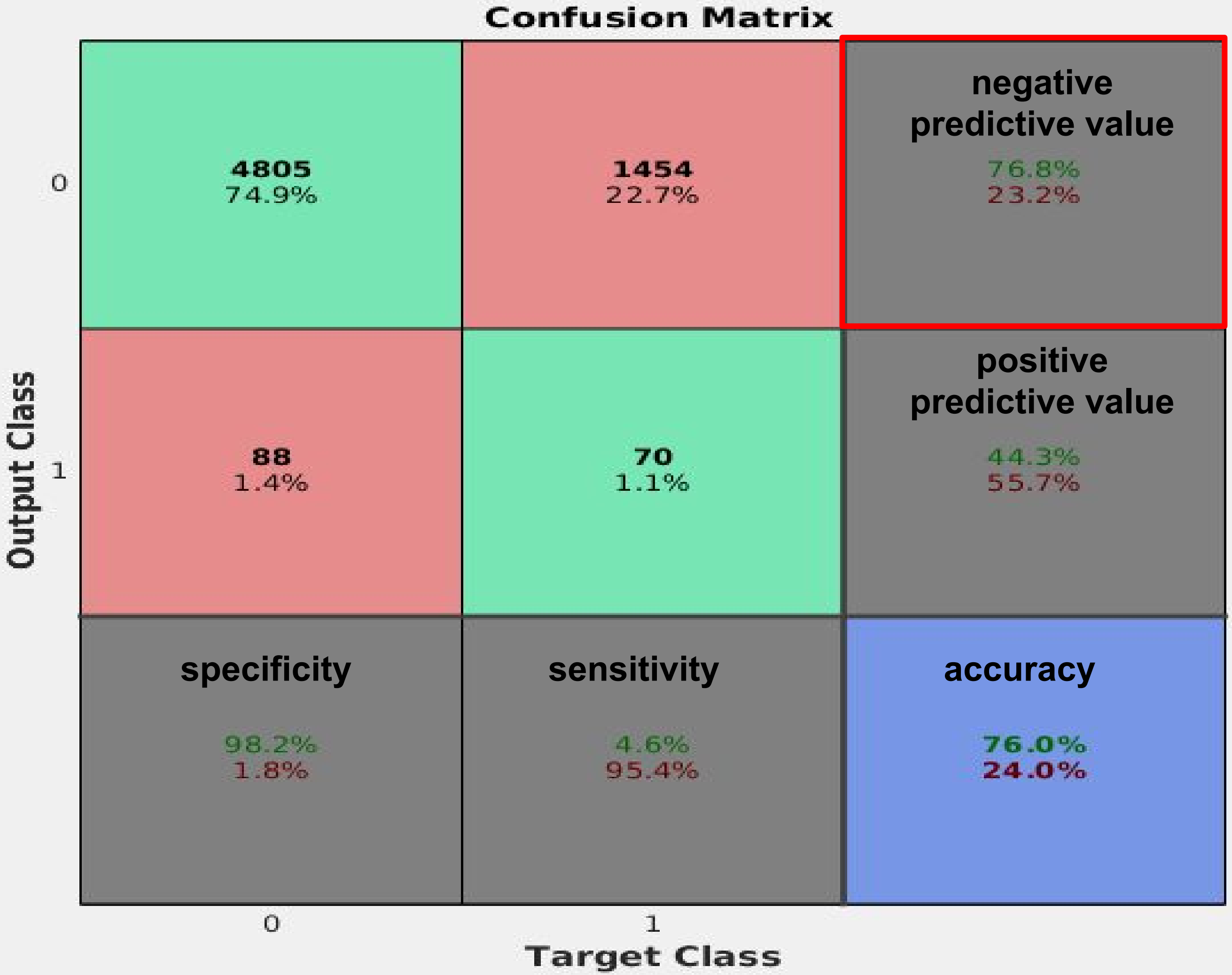
Confusion Matrix
4805
74.9%
1454
22.7%
negative predictive value
76.8%
23.2%
88
1.4%
70
1.1%
positive predictive value
44.3%
55.7%
specificity
98.2%
1.8%
sensitivity
4.6%
95.4%
accuracy
76.0%
24.0%
Output Class
0
1
Target Class
0
1

Sensitivity

- *Sensitivity=true deaths/(true deaths + false survivors)*

- <u>Given that a person is going to die</u>, how often will the test indicate death?

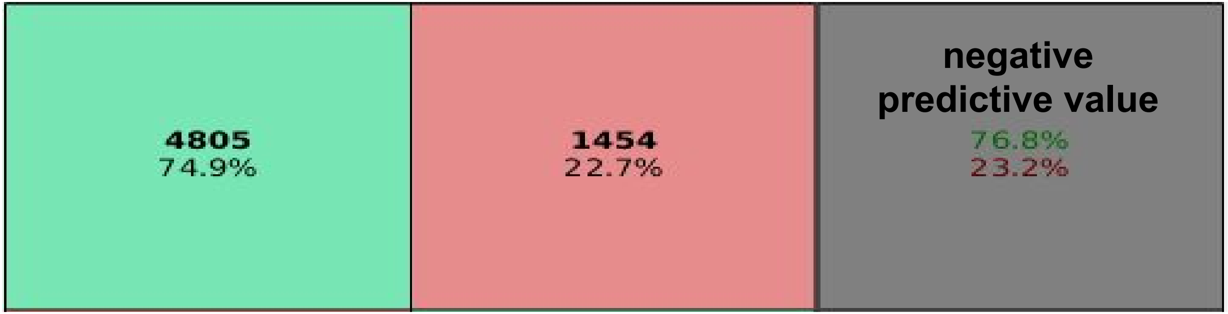


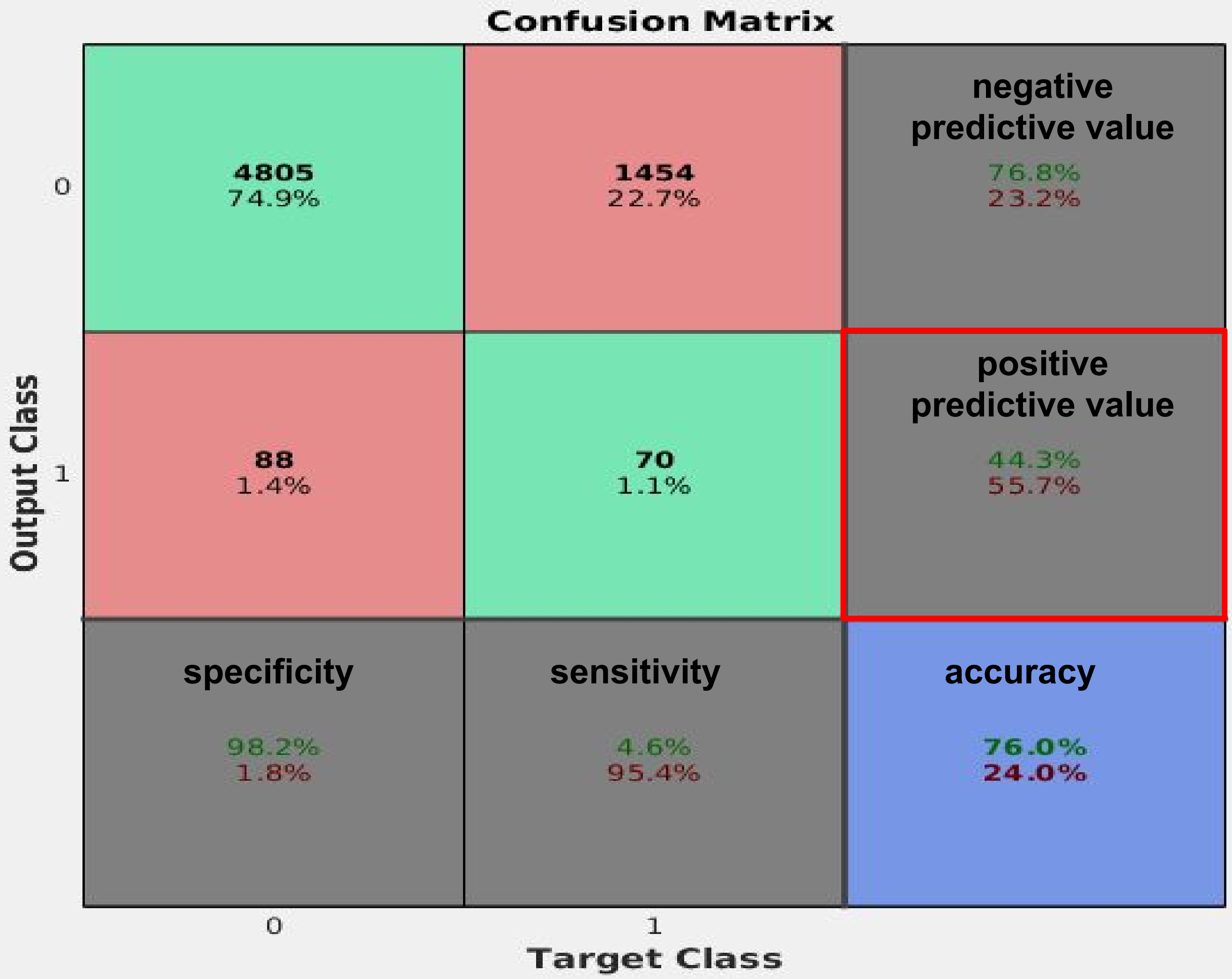

Confusion Matrix
4805
74.9%
1454
22.7%
negative
predictive value
76.8%
23.2%
88
1.4%
70
1.1%
positive
predictive value
44.3%
55.7%
specificity
98.2%
1.8%
sensitivity
4.6%
95.4%
accuracy
76.0%
24.0%
0
1
Output Class
0
1
Target Class

Negative Predictive value:

- *PV-= true survivals/(true survivals + false deaths)*

- <u>Given that the test predicts survival</u>, what is the probability that the patient actually survives?



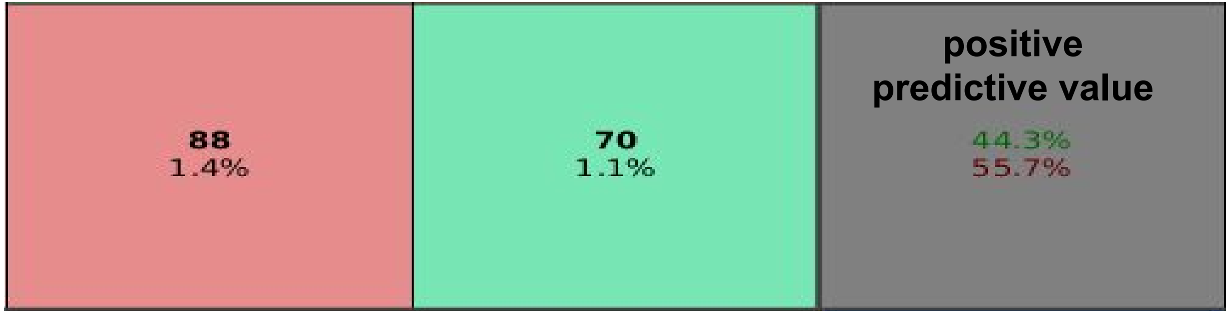


Confusion Matrix
4805
74.9%
1454
22.7%
negative
predictive value
76.8%
23.2%
88
1.4%
70
1.1%
positive
predictive value
44.3%
55.7%
specificity
98.2%
1.8%
sensitivity
4.6%
95.4%
accuracy
76.0%
24.0%
Output Class
0
1
Target Class
0
1

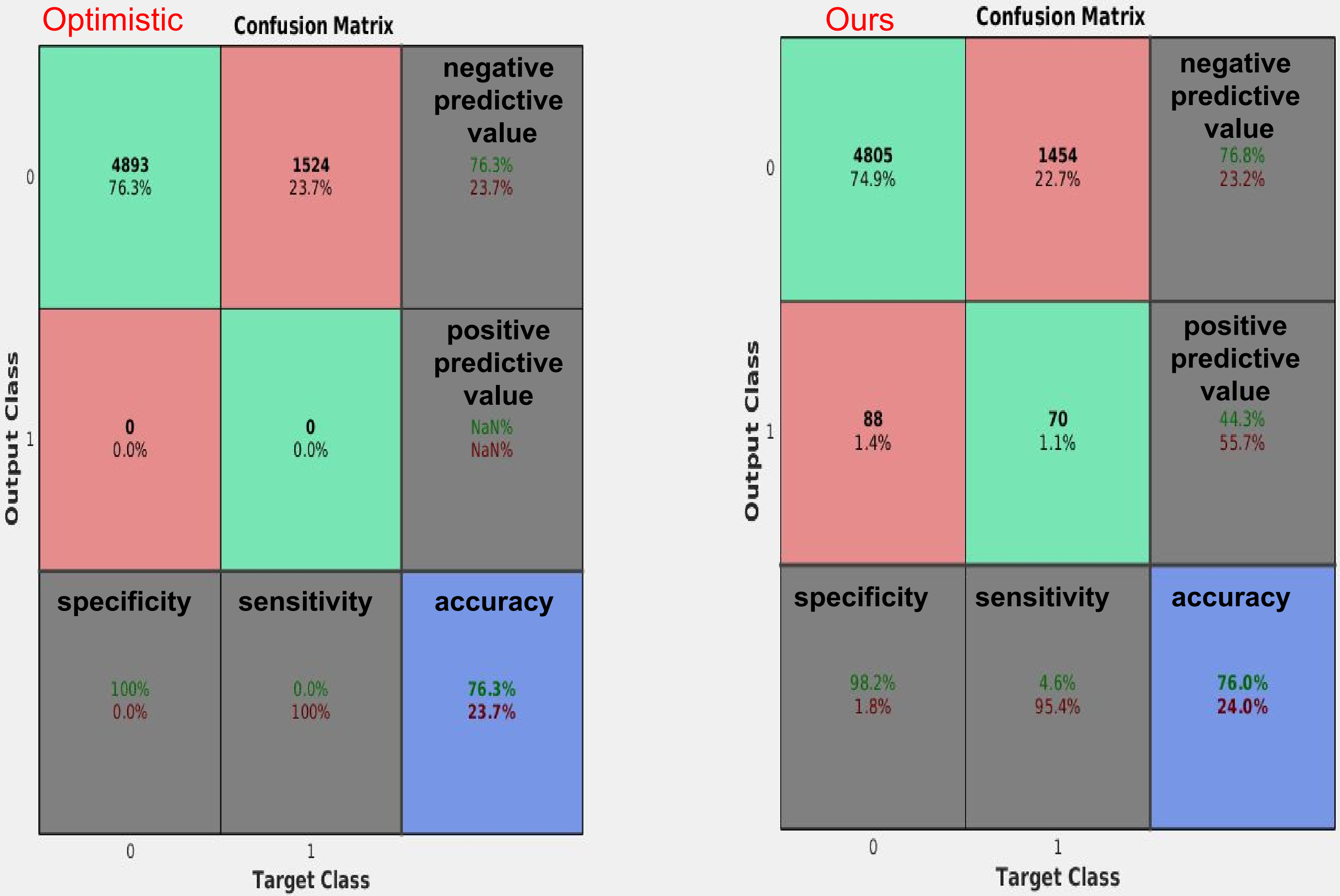
Positive Predictive value (PV+):

- *PV+= true deaths / (true deaths +false deaths)*

- Given that the test predicts death, what is the probability that the patient will die?



If we compare our approach against the Optimistic Approach, using these other metrics, how do we do?


Optimistic
Confusion Matrix
4893
76.3%
1524
23.7%
negative predictive value
76.3%
23.7%
0
0.0%
0
0.0%
positive predictive value
NaN%
NaN%
specificity
100%
0.0%
sensitivity
0.0%
100%
accuracy
76.3%
23.7%
Output Class
Target Class
0
1
Ours
Confusion Matrix
4805
74.9%
1454
22.7%
negative predictive value
76.8%
23.2%
88
1.4%
70
1.1%
positive predictive value
44.3%
55.7%
specificity
98.2%
1.8%
sensitivity
4.6%
95.4%
accuracy
76.0%
24.0%
Output Class
Target Class
0
1

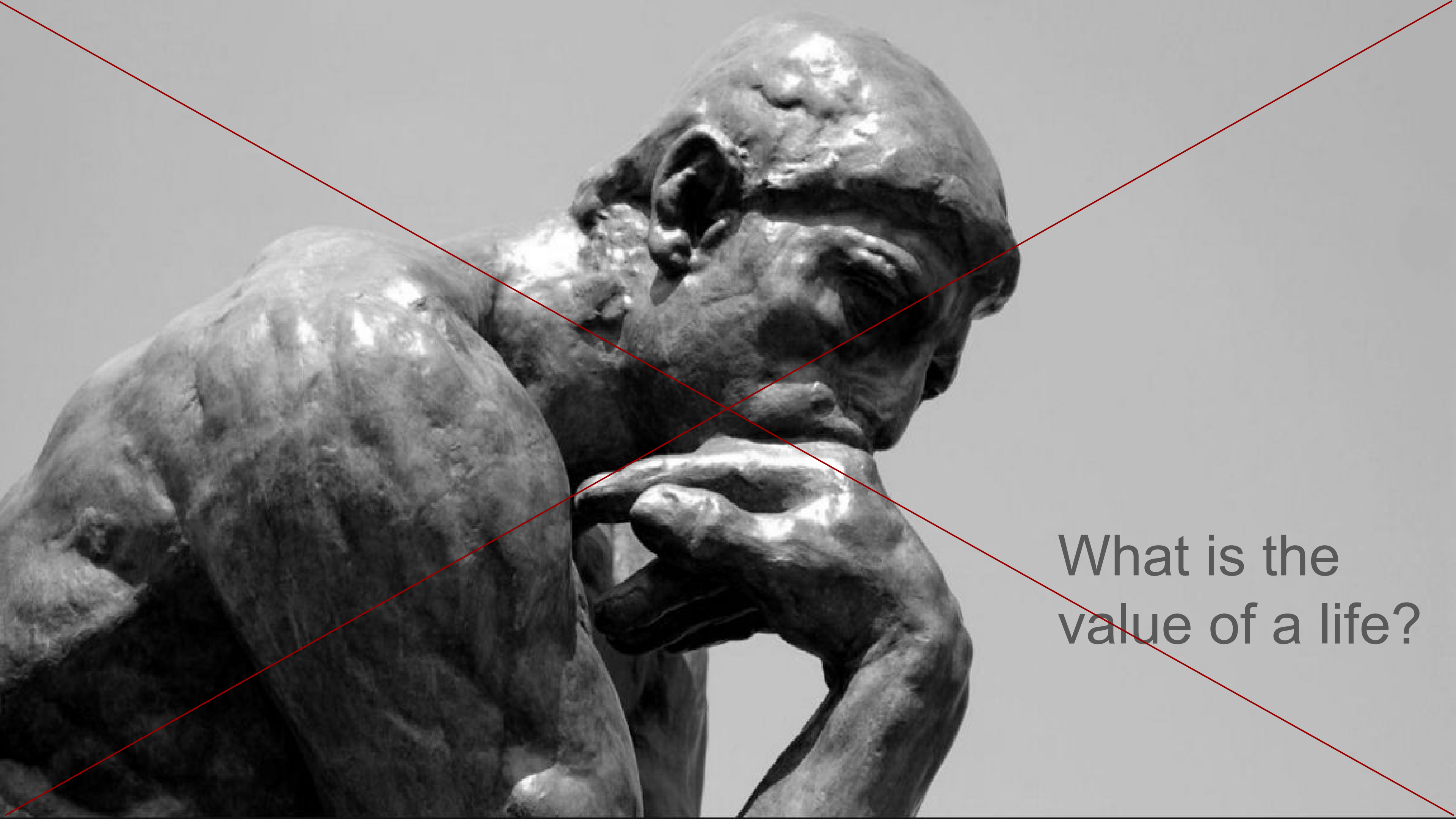
Given all the options, what is the standard performance metric when working with medical data?

- A good algorithm is both **sensitive** and **specific**.

- But deciding relative importance can be tricky

- Is it as bad to
  - predict survival given death, as it is to
  - predict death given survival?

What is the value of a life?


What is the value of a life?

- If everyone has an opinion about the relative importance of predicting survival vs. death, then let’s add a range of biases to our predictions and see how it does.
- We can do this, by adding or subtracting a constant value from our predictions

Let’s Bias The Optimist’s Algorithm

Optimist’s Original Prediction	Slight Bias	Modified Prediction	Modified Prediction > 0.5	Outcome
0	.1	0.1	0	1
0	.1	0.1	0	0
0	.1	0.1	0	1
0	.1	0.1	0	0

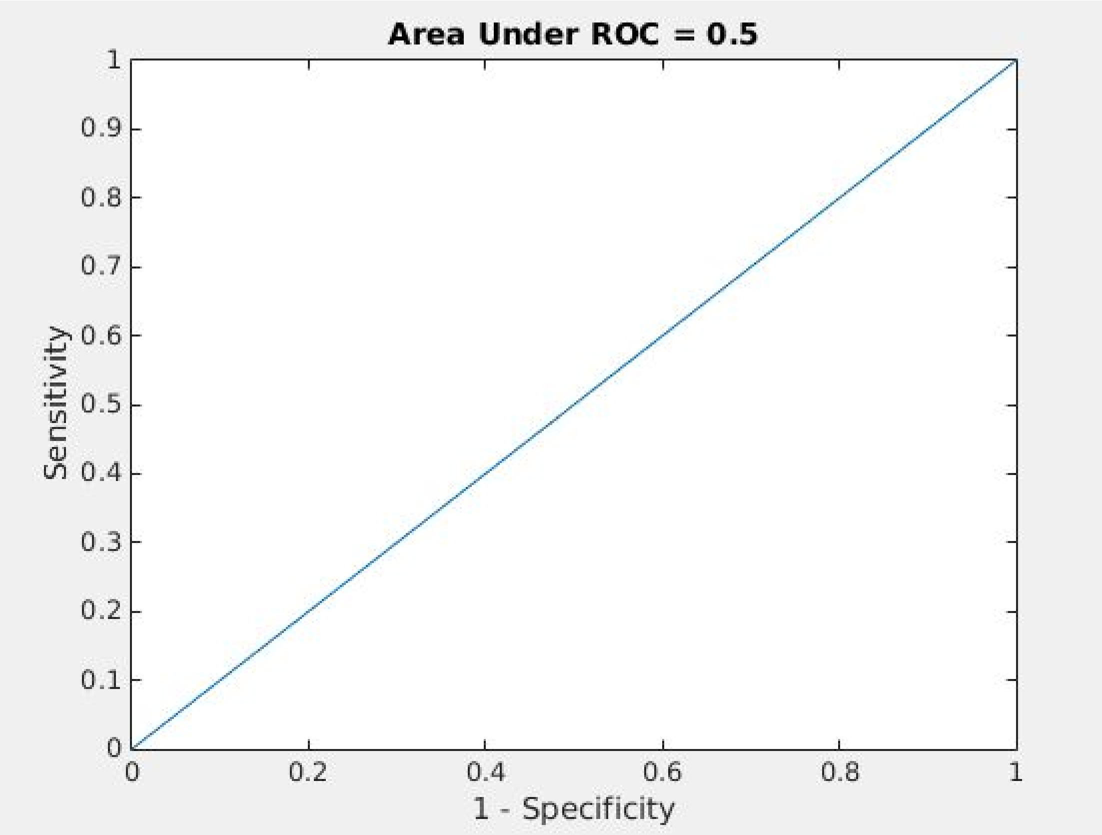
Optimist's Original Prediction	Pessimist Bias	Modified Prediction	Modified Prediction > 0.5	Outcome
0	1	1	1	1
0	1	1	1	0
0	1	1	1	1
0	1	1	1	0

Optimist's Original Prediction	Optimist Bias	Modified Prediction	Modified Prediction > 0.5	Outcome
0	-1	-1	0	1
0	-1	-1	0	0
0	-1	-1	0	1
0	-1	-1	0	0

```
%% STEP 10: Re-evaluate the Optimist
```

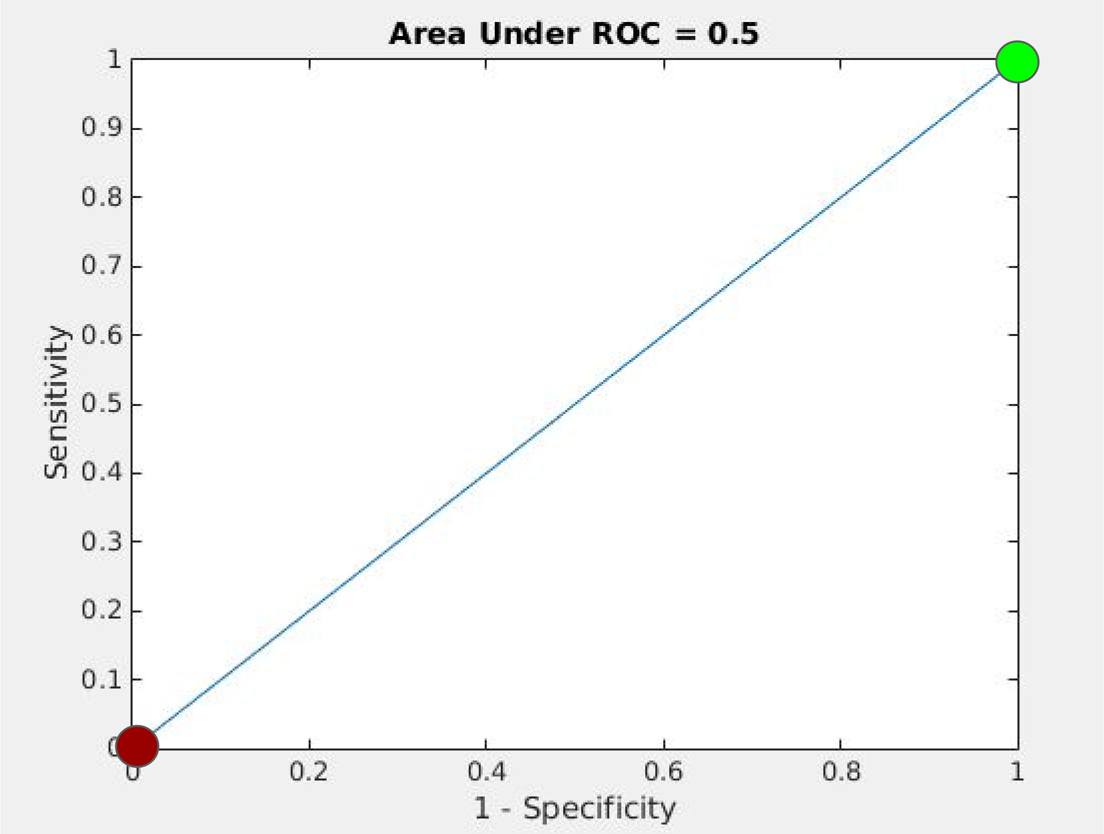
The Optimist's Algorithm

- Bias create two distinct predictions
- All 1s, or all 0s



```
%% STEP 10: Re-evaluate the Optimist
```

The Optimist's Algorithm



If predicting death given death is infinitely valuable.

If predicting survival given survival is infinitely valuable.

What about our Algorithm?

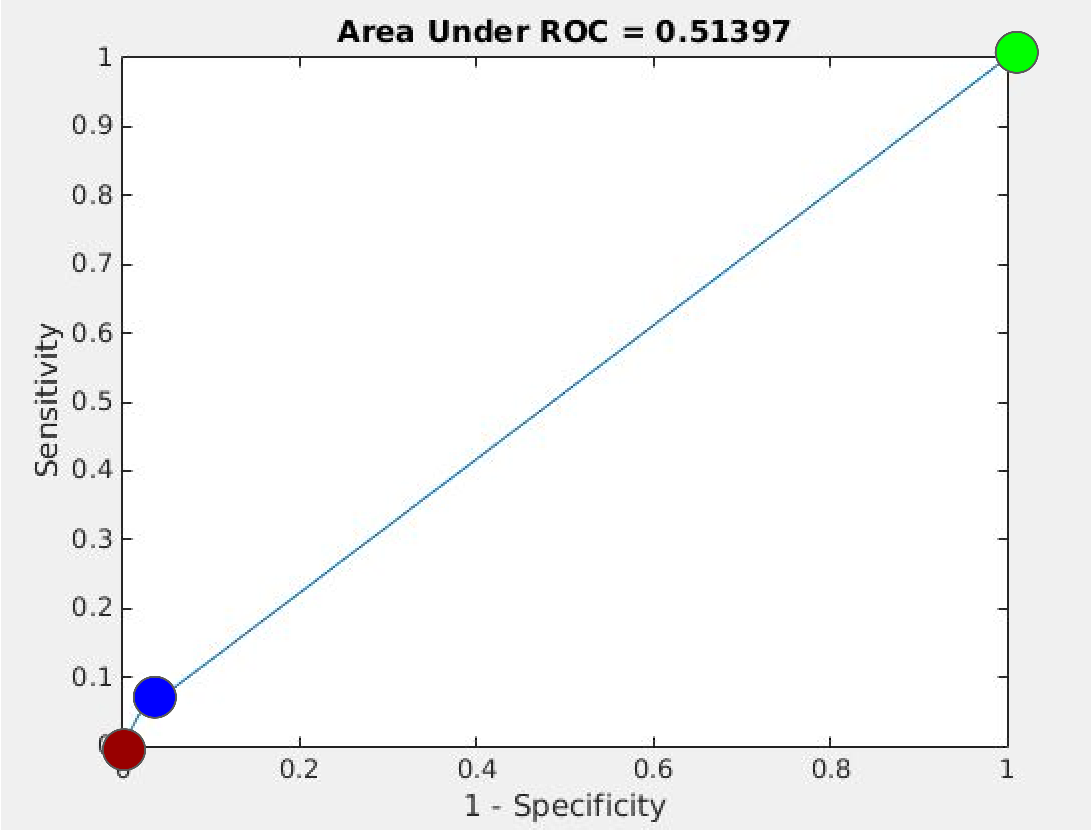
Our Original Prediction	Bias	Modified Prediction	Modified Prediction > 0.5	Outcome
1	.1	1.1	1	1
1	.1	1.1	1	0
0	.1	0.1	0	1
0	.1	0.1	0	0

Our Original Prediction	Pessimist Bias	Modified Prediction	Modified Prediction > 0.5	Outcome
1	1	2	1	1
1	1	2	1	0
0	1	1	1	1
0	1	1	1	0

Our Original Prediction	Optimist Bias	Modified Prediction	Modified Prediction > 0.5	Outcome
1	-1	0	0	1
1	-1	0	0	0
0	-1	-1	0	1
0	-1	-1	0	0

```
%% STEP 10: Re-evaluate Our Approach
```

Our Algorithm: Three Options



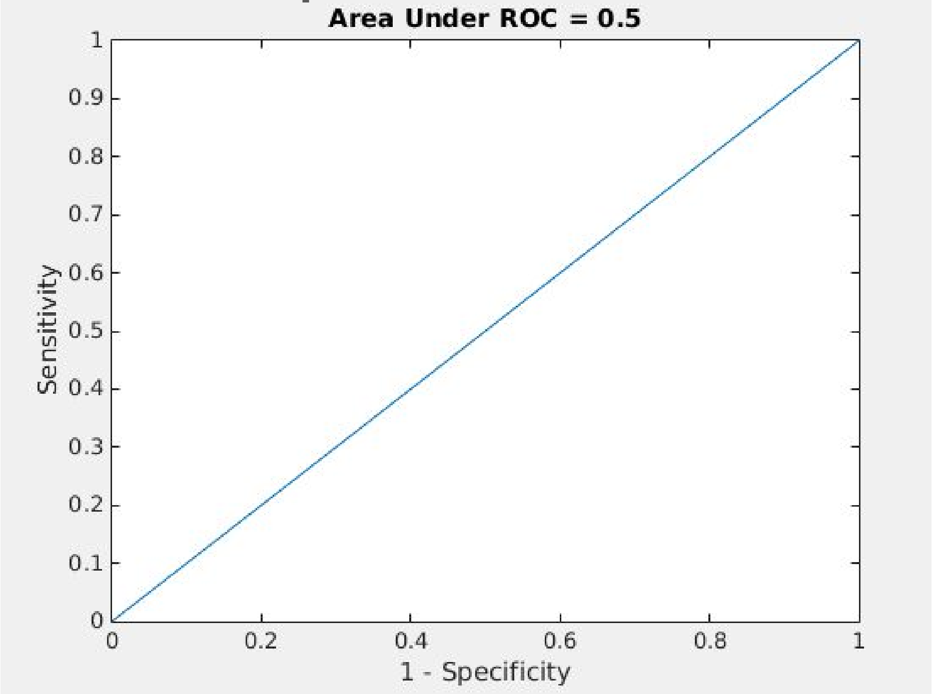
If predicting death given death is infinitely valuable.

If predicting survival given survival is infinitely valuable.

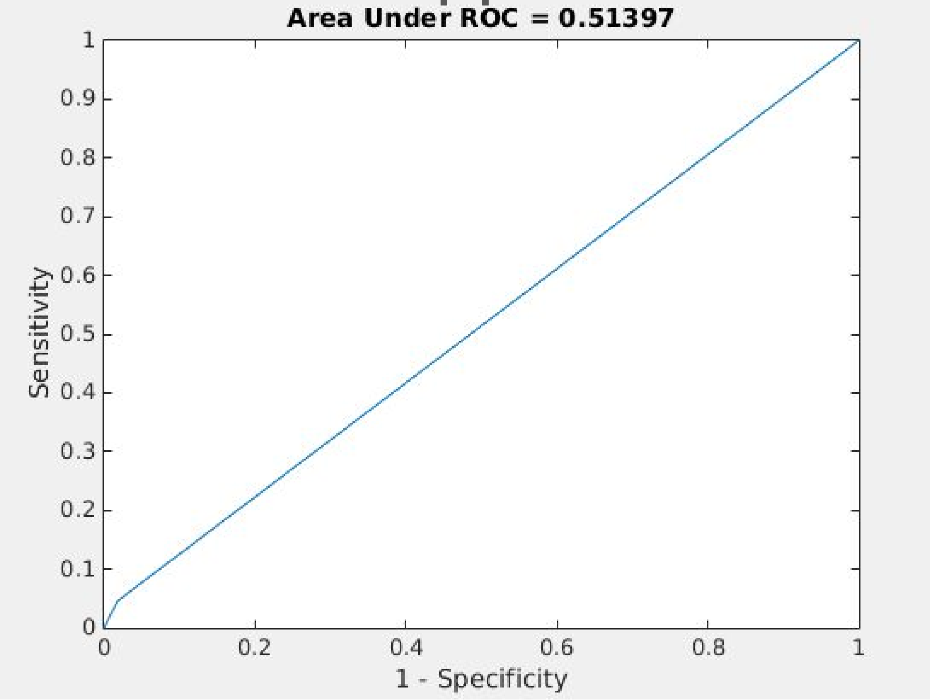
How do we know which is better?

Compare Every Option via *Area Under the Curve*

Optimist's

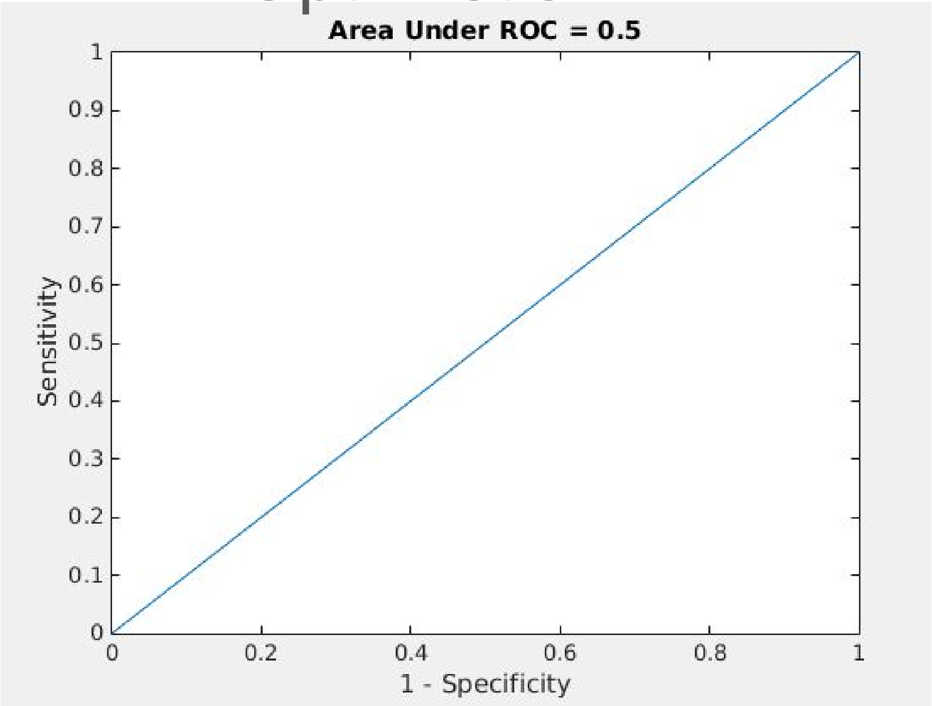


Our Approach

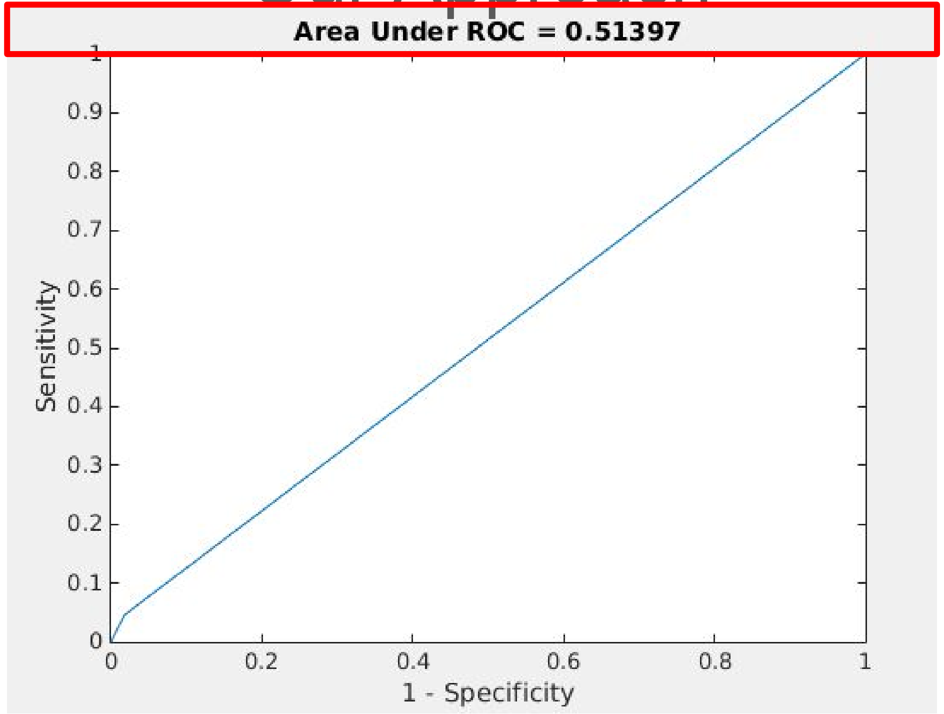


Compare Using the Area Under the Curve

Optimist's

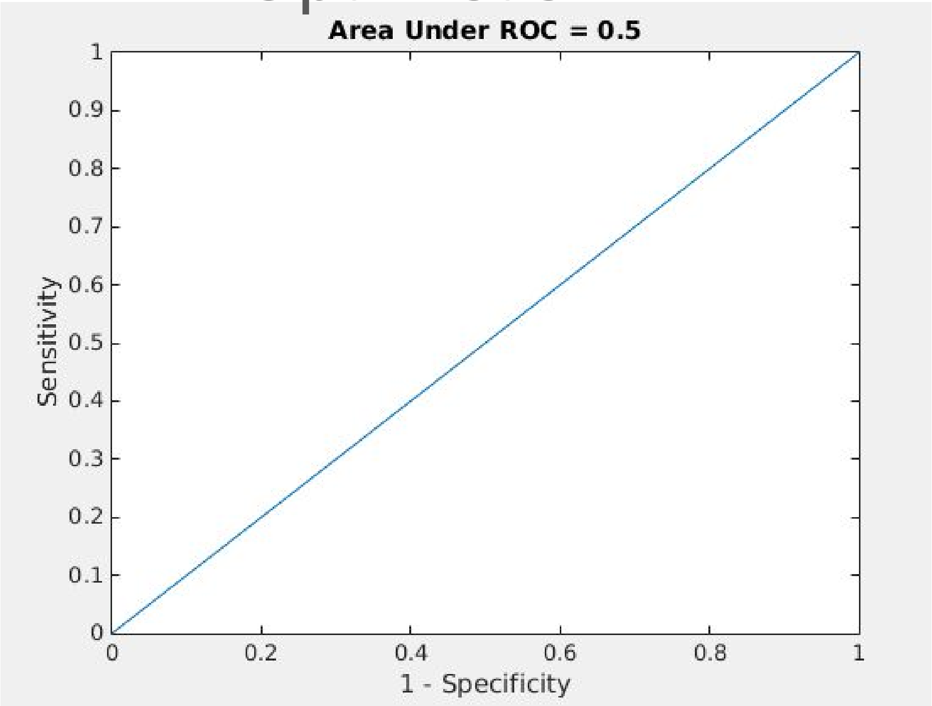


Our Approach

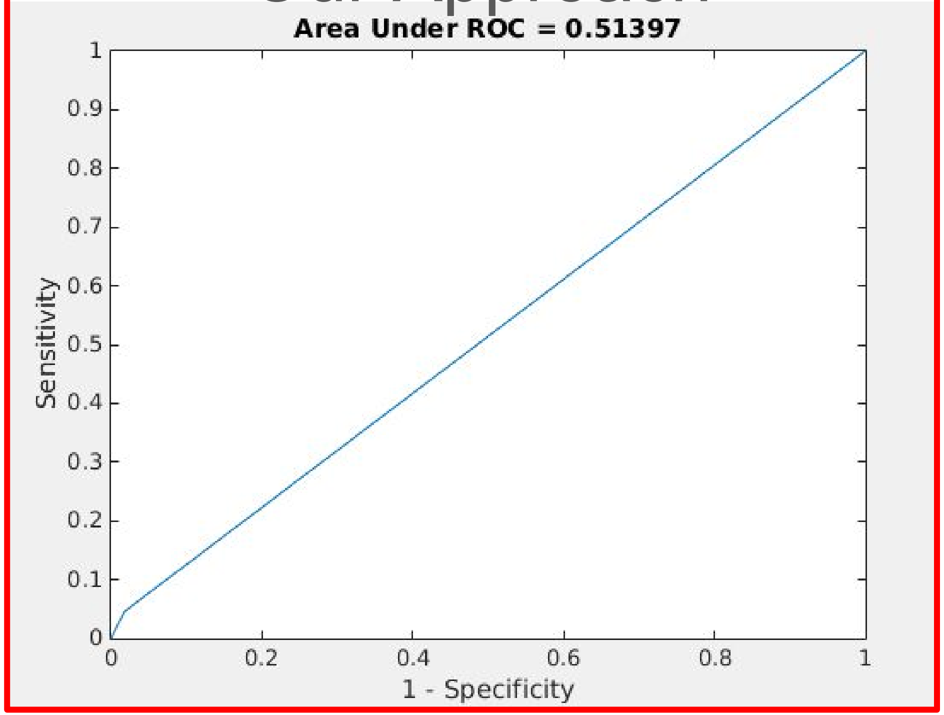


Compare Using the Area Under the Curve

Optimist's

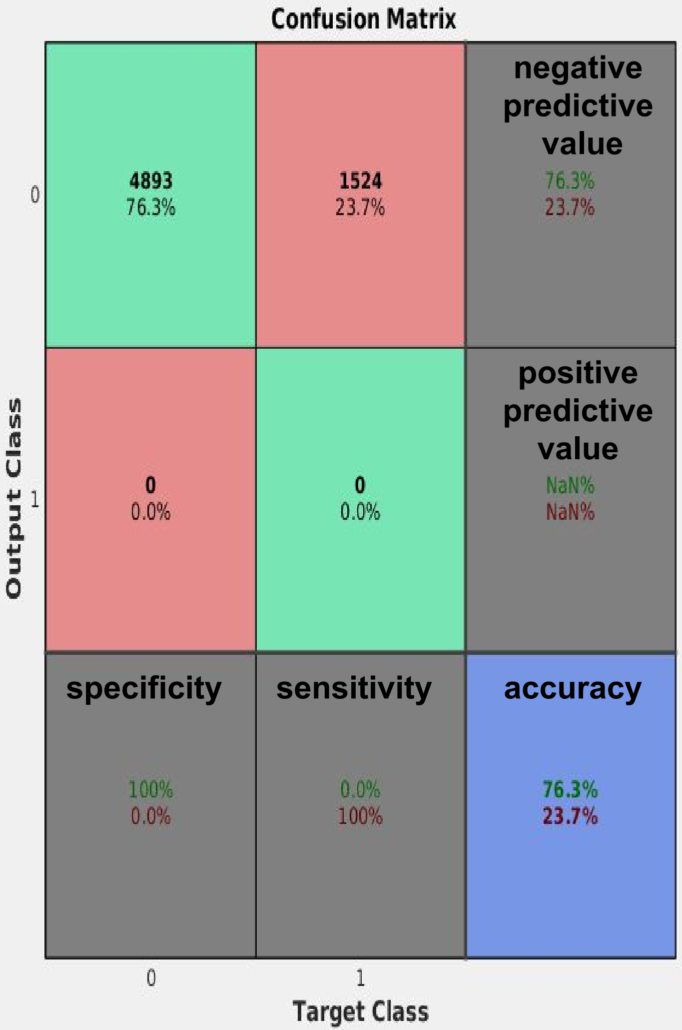


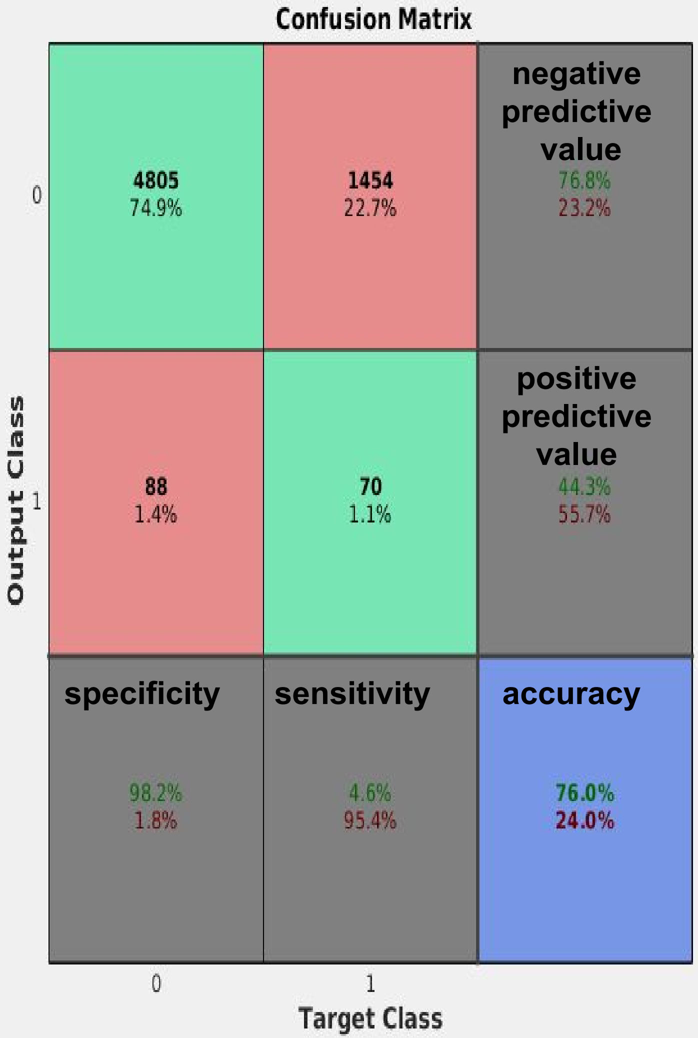
Our Approach



DON'T
KEEP CALM
IT'S
PARTY
TIME

Wait… Why are we so similar to the optimist’s algorithm?


Confusion Matrix
4893
76.3%
1524
23.7%
negative predictive value
76.3%
23.7%
0
0.0%
0
0.0%
positive predictive value
NaN%
NaN%
specificity
100%
0.0%
sensitivity
0.0%
100%
accuracy
76.3%
23.7%
Output Class
0
1
Target Class
0
1


Confusion Matrix
4805
74.9%
1454
22.7%
negative predictive value
76.8%
23.2%
88
1.4%
70
1.1%
positive predictive value
44.3%
55.7%
specificity
98.2%
1.8%
sensitivity
4.6%
95.4%
accuracy
76.0%
24.0%
Output Class
0
1
Target Class
0
1

Requiring all conditions to be satisfied is too rare.

<u>Democracy to the rescue!</u>

```
%% STEP 11: The Democracy Algorithm
```

Let’s Make a <u>BETTER</u> Better Black Box

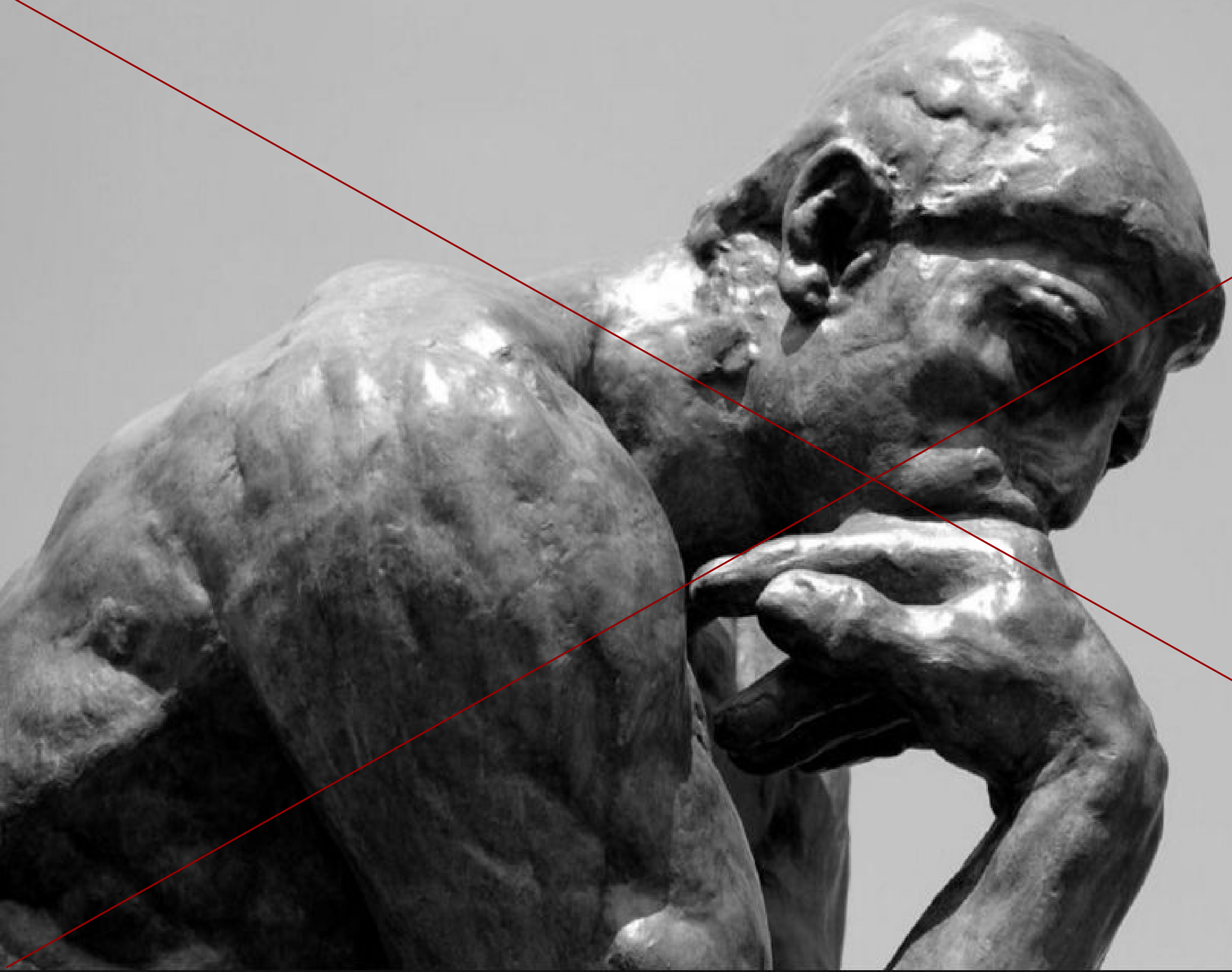
```
'ICUSTAYID'
'OUTCOME'
'Age'
'HeartRateMin'
'HeartRateMax'
'MeanBPMin'
'MeanBPMax'
'RespRateMin'
'RespRateMax'
'GCSMin'
'GCSMax'
'BILIRUBINmin'
'BILIRUBINmax'
'CREATININEmin
'CREATININEmax
'HEMOGLOBINmin
'HEMOGLOBINmax
'SODIUMmin'
'SODIUMmax'
'WBCmin'
'WBCmax'
```

A BETTER Better
Black Box
(Literally)

Inside The BETTER Better Black Box

```
votes =      ( (Age < 30) +
               (Age > 75) +
               (WBCmax > 15) +
               (WBCmin > 15) +
               (HeartRateMax > 125) +
               (HeartRateMin > 100) +
               (HeartRateMin < 40)
             ) / 7
prediction = death if votes > ...
```

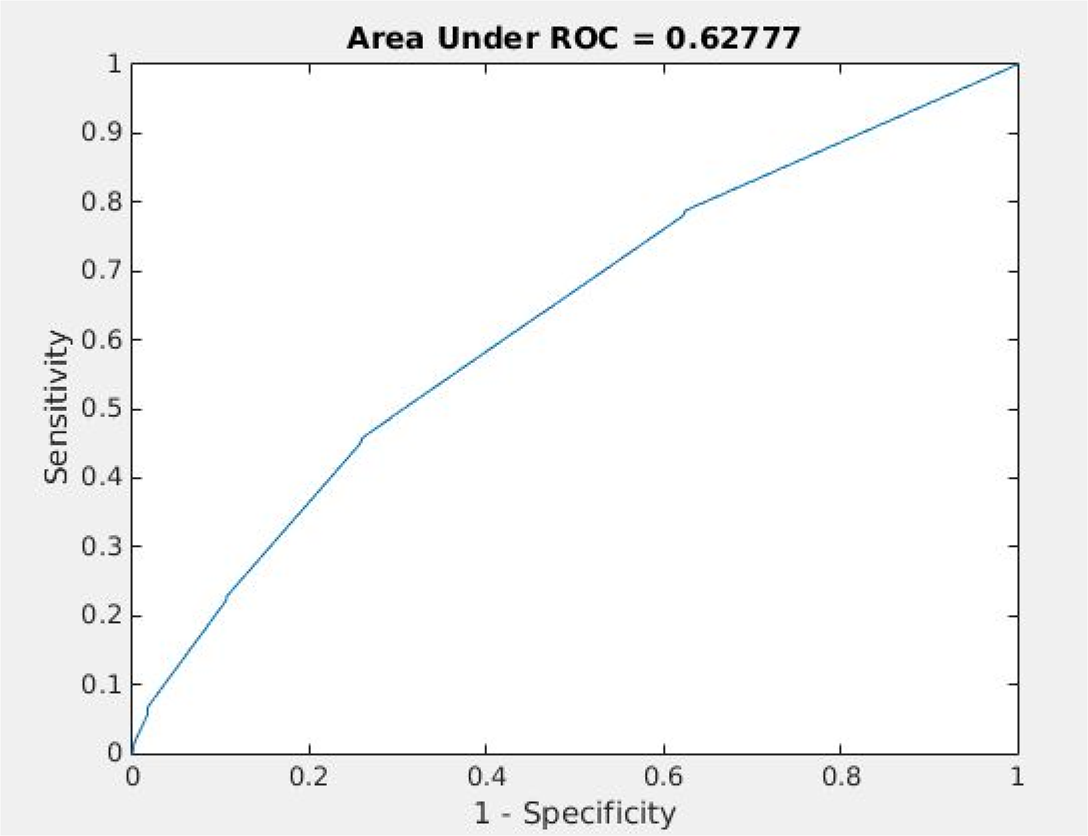
How many votes are enough?



How many votes are enough?

```
%% STEP 11: The Democracy Algorithm
```

The Democracy Algorithm



But can we do better…

Perhaps not all features are created equal.

<u>Aristocracy?</u>

```
%% STEP 12: The Aristocracy Algorithm
```

Let’s Make a Philosopher King Black Box

```
'ICUSTAYID'
'OUTCOME'
'Age'
'HeartRateMin'
'HeartRateMax'
'MeanBPMin'
'MeanBPMax'
'RespRateMin'
'RespRateMax'
'GCSMin'
'GCSMax'
'BILIRUBINmin'
'BILIRUBINmax'
'CREATININEmin
'CREATININEmax
'HEMOGLOBINmin
'HEMOGLOBINmax
'SODIUMmin'
'SODIUMmax'
'WBCmin'
'WBCmax'
```

A Philosopher King
Black Box
(Literally)

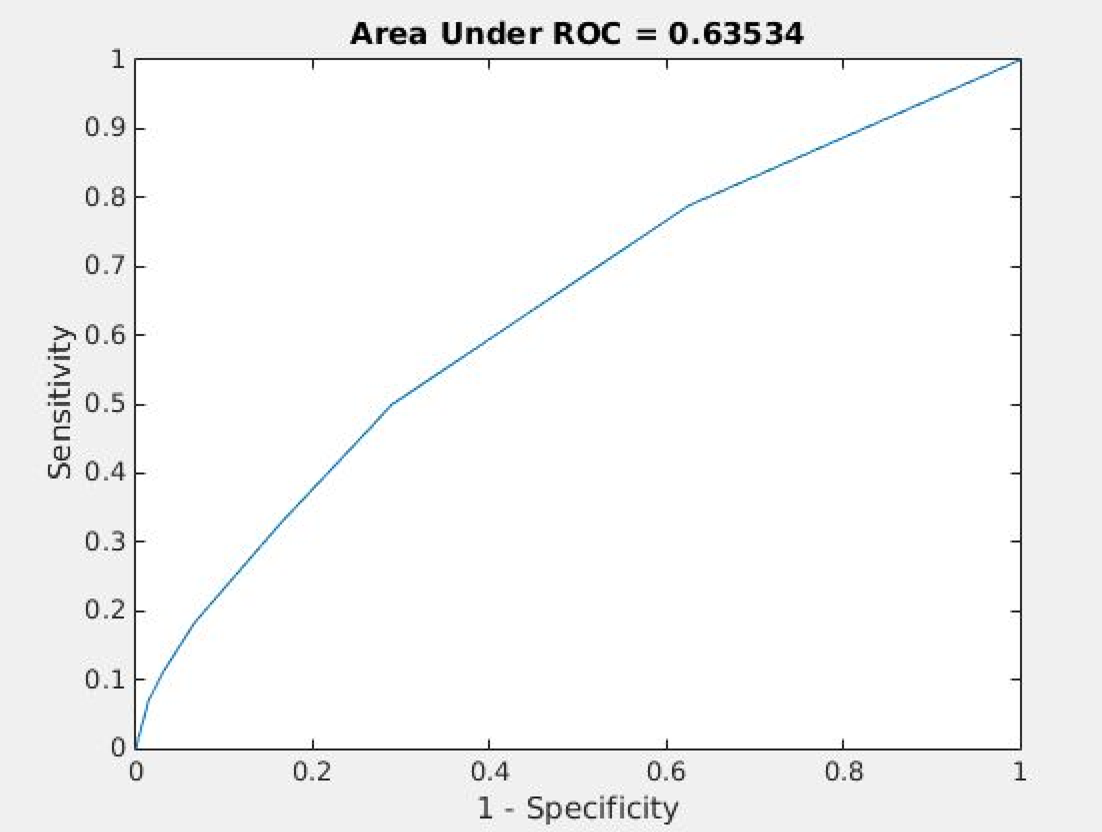
Inside The Philosopher King’s Black Box

```
votes =     4 * ((Age < 30) +
             1 * (Age > 75) +
             1 * (WBCmax > 15) +
             1 * (WBCmin > 15) +
             1 * (HeartRateMax > 125) +
             3 * (HeartRateMin > 100) +
             3 * (HeartRateMin < 40)) / 14

prediction = 1 if votes > ...
```

```
%% STEP 12: The Aristocracy Algorithm
```

The Philosopher King Algorithm… Plato was right...



What can we conclude

- The Optimist's Approach
  - Area under the curve = 0.50
- Our First Approach
  - Area under the curve = 0.51
- Democracy
  - Area under the curve = 0.62
- Aristocracy
  - Area under the curve = 0.64

What can we conclude

- The Optimist’s Approach
  - Area under the curve = 0.50
- Our First Approach
  - Area under the curve = 0.51
- Democracy
  - Area under the curve = 0.62
- Aristocracy
  - Area under the curve = 0.64

Plato Socrates Aristotle

Before we get carried away…

What Has Human Learning Taught Us?

- Features with distributions that separate the outcomes of interest do a good job in classification.

- If done correctly, combining multiple weak features can make for a strong classifier.

- Not all features are equally important, some should be considered more strongly than others.

Here’s how it connects to Machine Learning

- ML Identifies features that separate the cases of interest, automatically!

- ML combines multiple weak features, automatically.

- ML considered some features more strongly than others, automatically!

Are we done?

Wait!
What about Jim!

```
%% STEP 13: Let's Try a Specific Subject [290851]
```

Jim’s ICUSTAY_ID - 290851

- Prediction is 0?
  - Could there be a bug?

- Let’s Investigate