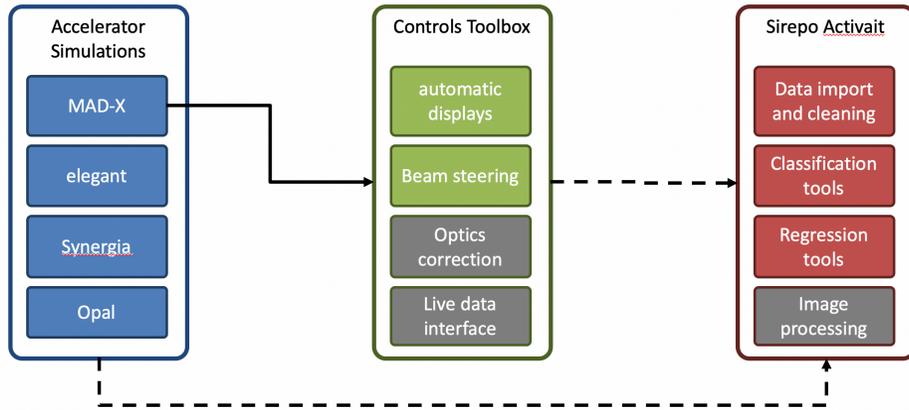


A Cloud Based Toolbox for Accelerator Controls Interfaces and Optimization

J. P. Edelen, E. Carlin, M. Keilman, P. Moeller, R. Nagler RadiaSoft LLC, Boulder, CO



A Browser Based workflow for Accelerator Controls



Lattice Construction

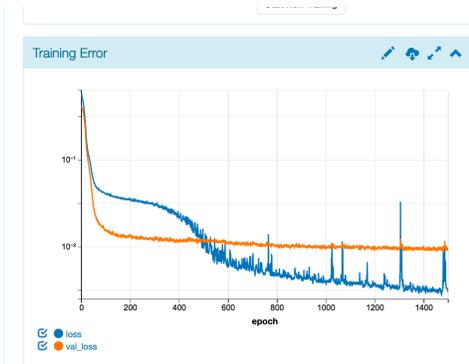
Name	Description	Elements	Start-End	Length	Bend
all	(body,S1,body)	13	6.200m	6.300m	20.0°
beamline	(D1,K1,Q1,Q2,Q3,Q4,Q5,Q6,Q7,Q8,Q9,Q10,Q11,Q12,Q13,Q14,Q15,Q16,Q17,Q18,Q19,Q20,Q21,Q22,Q23,Q24,Q25,Q26,Q27,Q28,Q29,Q30,Q31,Q32,Q33,Q34,Q35,Q36,Q37,Q38,Q39,Q40,Q41,Q42,Q43,Q44,Q45,Q46,Q47,Q48,Q49,Q50,Q51,Q52,Q53,Q54,Q55,Q56,Q57,Q58,Q59,Q60,Q61,Q62,Q63,Q64,Q65,Q66,Q67,Q68,Q69,Q70,Q71,Q72,Q73,Q74,Q75,Q76,Q77,Q78,Q79,Q80,Q81,Q82,Q83,Q84,Q85,Q86,Q87,Q88,Q89,Q90,Q91,Q92,Q93,Q94,Q95,Q96,Q97,Q98,Q99,Q100,Q101,Q102,Q103,Q104,Q105,Q106,Q107,Q108,Q109,Q110,Q111,Q112,Q113,Q114,Q115,Q116,Q117,Q118,Q119,Q120,Q121,Q122,Q123,Q124,Q125,Q126,Q127,Q128,Q129,Q130,Q131,Q132,Q133,Q134,Q135,Q136,Q137,Q138,Q139,Q140,Q141,Q142,Q143,Q144,Q145,Q146,Q147,Q148,Q149,Q150,Q151,Q152,Q153,Q154,Q155,Q156,Q157,Q158,Q159,Q160,Q161,Q162,Q163,Q164,Q165,Q166,Q167,Q168,Q169,Q170,Q171,Q172,Q173,Q174,Q175,Q176,Q177,Q178,Q179,Q180,Q181,Q182,Q183,Q184,Q185,Q186,Q187,Q188,Q189,Q190,Q191,Q192,Q193,Q194,Q195,Q196,Q197,Q198,Q199,Q200,Q201,Q202,Q203,Q204,Q205,Q206,Q207,Q208,Q209,Q210,Q211,Q212,Q213,Q214,Q215,Q216,Q217,Q218,Q219,Q220,Q221,Q222,Q223,Q224,Q225,Q226,Q227,Q228,Q229,Q230,Q231,Q232,Q233,Q234,Q235,Q236,Q237,Q238,Q239,Q240,Q241,Q242,Q243,Q244,Q245,Q246,Q247,Q248,Q249,Q250,Q251,Q252,Q253,Q254,Q255,Q256,Q257,Q258,Q259,Q260,Q261,Q262,Q263,Q264,Q265,Q266,Q267,Q268,Q269,Q270,Q271,Q272,Q273,Q274,Q275,Q276,Q277,Q278,Q279,Q280,Q281,Q282,Q283,Q284,Q285,Q286,Q287,Q288,Q289,Q290,Q291,Q292,Q293,Q294,Q295,Q296,Q297,Q298,Q299,Q300,Q301,Q302,Q303,Q304,Q305,Q306,Q307,Q308,Q309,Q310,Q311,Q312,Q313,Q314,Q315,Q316,Q317,Q318,Q319,Q320,Q321,Q322,Q323,Q324,Q325,Q326,Q327,Q328,Q329,Q330,Q331,Q332,Q333,Q334,Q335,Q336,Q337,Q338,Q339,Q340,Q341,Q342,Q343,Q344,Q345,Q346,Q347,Q348,Q349,Q350,Q351,Q352,Q353,Q354,Q355,Q356,Q357,Q358,Q359,Q360,Q361,Q362,Q363,Q364,Q365,Q366,Q367,Q368,Q369,Q370,Q371,Q372,Q373,Q374,Q375,Q376,Q377,Q378,Q379,Q380,Q381,Q382,Q383,Q384,Q385,Q386,Q387,Q388,Q389,Q390,Q391,Q392,Q393,Q394,Q395,Q396,Q397,Q398,Q399,Q400,Q401,Q402,Q403,Q404,Q405,Q406,Q407,Q408,Q409,Q410,Q411,Q412,Q413,Q414,Q415,Q416,Q417,Q418,Q419,Q420,Q421,Q422,Q423,Q424,Q425,Q426,Q427,Q428,Q429,Q430,Q431,Q432,Q433,Q434,Q435,Q436,Q437,Q438,Q439,Q440,Q441,Q442,Q443,Q444,Q445,Q446,Q447,Q448,Q449,Q450,Q451,Q452,Q453,Q454,Q455,Q456,Q457,Q458,Q459,Q460,Q461,Q462,Q463,Q464,Q465,Q466,Q467,Q468,Q469,Q470,Q471,Q472,Q473,Q474,Q475,Q476,Q477,Q478,Q479,Q480,Q481,Q482,Q483,Q484,Q485,Q486,Q487,Q488,Q489,Q490,Q491,Q492,Q493,Q494,Q495,Q496,Q497,Q498,Q499,Q500,Q501,Q502,Q503,Q504,Q505,Q506,Q507,Q508,Q509,Q510,Q511,Q512,Q513,Q514,Q515,Q516,Q517,Q518,Q519,Q520,Q521,Q522,Q523,Q524,Q525,Q526,Q527,Q528,Q529,Q530,Q531,Q532,Q533,Q534,Q535,Q536,Q537,Q538,Q539,Q540,Q541,Q542,Q543,Q544,Q545,Q546,Q547,Q548,Q549,Q550,Q551,Q552,Q553,Q554,Q555,Q556,Q557,Q558,Q559,Q560,Q561,Q562,Q563,Q564,Q565,Q566,Q567,Q568,Q569,Q570,Q571,Q572,Q573,Q574,Q575,Q576,Q577,Q578,Q579,Q580,Q581,Q582,Q583,Q584,Q585,Q586,Q587,Q588,Q589,Q590,Q591,Q592,Q593,Q594,Q595,Q596,Q597,Q598,Q599,Q600,Q601,Q602,Q603,Q604,Q605,Q606,Q607,Q608,Q609,Q610,Q611,Q612,Q613,Q614,Q615,Q616,Q617,Q618,Q619,Q620,Q621,Q622,Q623,Q624,Q625,Q626,Q627,Q628,Q629,Q630,Q631,Q632,Q633,Q634,Q635,Q636,Q637,Q638,Q639,Q640,Q641,Q642,Q643,Q644,Q645,Q646,Q647,Q648,Q649,Q650,Q651,Q652,Q653,Q654,Q655,Q656,Q657,Q658,Q659,Q660,Q661,Q662,Q663,Q664,Q665,Q666,Q667,Q668,Q669,Q670,Q671,Q672,Q673,Q674,Q675,Q676,Q677,Q678,Q679,Q680,Q681,Q682,Q683,Q684,Q685,Q686,Q687,Q688,Q689,Q690,Q691,Q692,Q693,Q694,Q695,Q696,Q697,Q698,Q699,Q700,Q701,Q702,Q703,Q704,Q705,Q706,Q707,Q708,Q709,Q710,Q711,Q712,Q713,Q714,Q715,Q716,Q717,Q718,Q719,Q720,Q721,Q722,Q723,Q724,Q725,Q726,Q727,Q728,Q729,Q730,Q731,Q732,Q733,Q734,Q735,Q736,Q737,Q738,Q739,Q740,Q741,Q742,Q743,Q744,Q745,Q746,Q747,Q748,Q749,Q750,Q751,Q752,Q753,Q754,Q755,Q756,Q757,Q758,Q759,Q760,Q761,Q762,Q763,Q764,Q765,Q766,Q767,Q768,Q769,Q770,Q771,Q772,Q773,Q774,Q775,Q776,Q777,Q778,Q779,Q780,Q781,Q782,Q783,Q784,Q785,Q786,Q787,Q788,Q789,Q790,Q791,Q792,Q793,Q794,Q795,Q796,Q797,Q798,Q799,Q800,Q801,Q802,Q803,Q804,Q805,Q806,Q807,Q808,Q809,Q810,Q811,Q812,Q813,Q814,Q815,Q816,Q817,Q818,Q819,Q820,Q821,Q822,Q823,Q824,Q825,Q826,Q827,Q828,Q829,Q830,Q831,Q832,Q833,Q834,Q835,Q836,Q837,Q838,Q839,Q840,Q841,Q842,Q843,Q844,Q845,Q846,Q847,Q848,Q849,Q850,Q851,Q852,Q853,Q854,Q855,Q856,Q857,Q858,Q859,Q860,Q861,Q862,Q863,Q864,Q865,Q866,Q867,Q868,Q869,Q870,Q871,Q872,Q873,Q874,Q875,Q876,Q877,Q878,Q879,Q880,Q881,Q882,Q883,Q884,Q885,Q886,Q887,Q888,Q889,Q890,Q891,Q892,Q893,Q894,Q895,Q896,Q897,Q898,Q899,Q900,Q901,Q902,Q903,Q904,Q905,Q906,Q907,Q908,Q909,Q910,Q911,Q912,Q913,Q914,Q915,Q916,Q917,Q918,Q919,Q920,Q921,Q922,Q923,Q924,Q925,Q926,Q927,Q928,Q929,Q930,Q931,Q932,Q933,Q934,Q935,Q936,Q937,Q938,Q939,Q940,Q941,Q942,Q943,Q944,Q945,Q946,Q947,Q948,Q949,Q950,Q951,Q952,Q953,Q954,Q955,Q956,Q957,Q958,Q959,Q960,Q961,Q962,Q963,Q964,Q965,Q966,Q967,Q968,Q969,Q970,Q971,Q972,Q973,Q974,Q975,Q976,Q977,Q978,Q979,Q980,Q981,Q982,Q983,Q984,Q985,Q986,Q987,Q988,Q989,Q990,Q991,Q992,Q993,Q994,Q995,Q996,Q997,Q998,Q999,1000)				

Sample controls interface

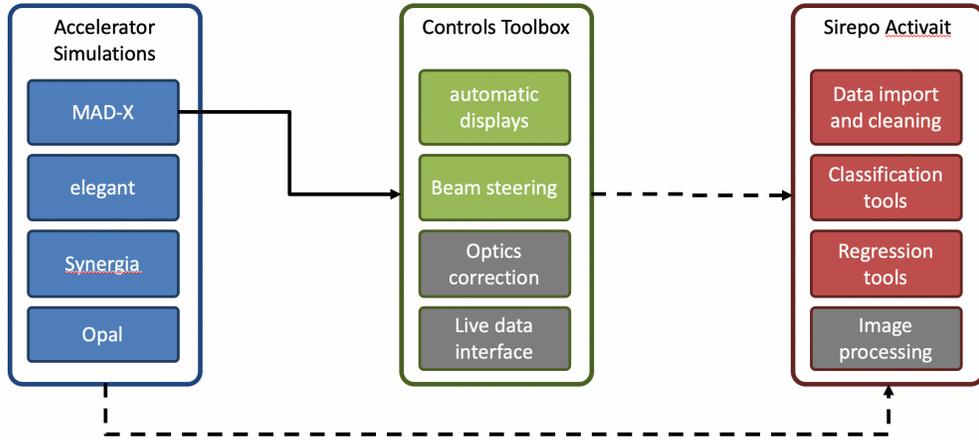
Kickers [A]	Quads [A]	Monitors
CORR1: current = -0.000248; vcurrent = 0.000129;	QUAD1: current = 1.216968;	BPM1 0.000898 -0.000947
CORR1: current = -0.000289;	QUAD2: current = -1.216968;	BPMX1 -0.000065
CORR1: current = -0.000142;	QUAD3: current = 1.216968;	BPMY1 0.000042
CORR2: current = -0.00001;	QUAD4: current = -1.216968;	BPMX2 0.000007
CORR2: current = 0.000031;		BPMY2 -0.000048
CORR2: current = -0.000143; vcurrent = 0.000056;		BPM2 -0.000012 0.000018

Machine learning with Sirepo Activait

Layer	Dimensionality	Activation
Densely Connected NN	20	Rectified Linear Unit (relu)
Gaussian Noise	0.01	
Densely Connected NN	10	Rectified Linear Unit (relu)
Gaussian Noise	0.01	
Densely Connected NN	20	Rectified Linear Unit (relu)
Gaussian Noise	0.01	
Densely Connected NN	10	Linear (identity)
Densely Connected NN	10	Linear (identity)

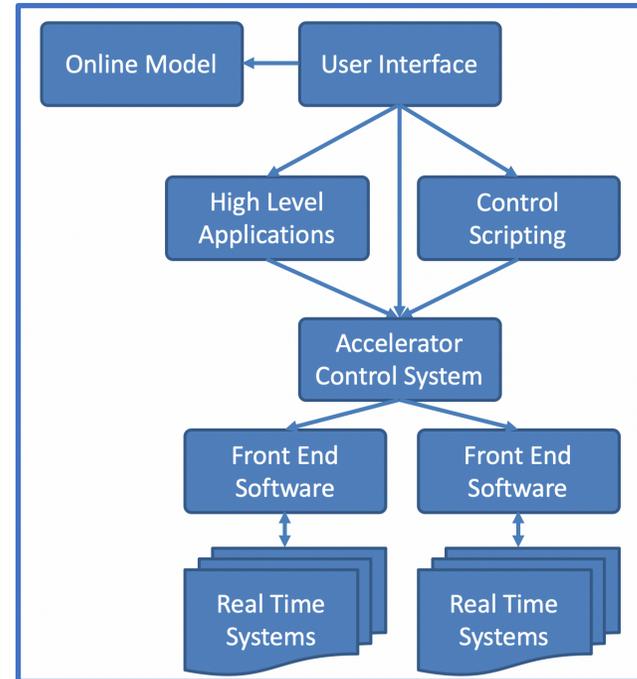


A Browser Based workflow for Accelerator Controls

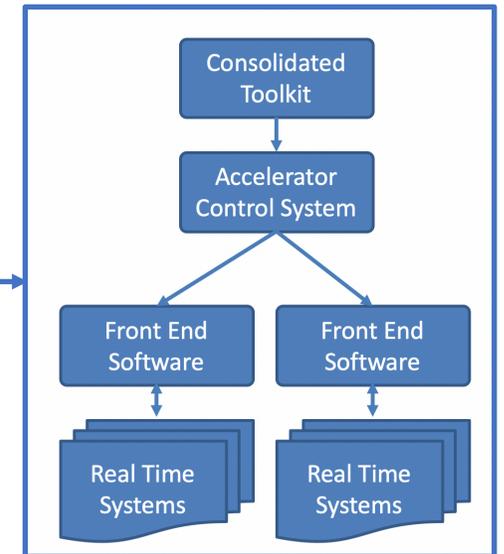


- User interface to control systems
 - Synoptic displays
 - Custom interfaces
 - Communicate directly with front ends or with high level applications
- High level applications / control scripting
 - Programs to monitor and adjust subsystems
 - Python / machine language scripts / ocelot / others
- Online models
 - Acquire machine parameters directly or through UI
- Real Time Systems
 - Often FPGA driven or other embedded system

Common current workflow for accelerator controls



Proposed workflow by integrating and consolidating into a single application



Lattice Construction

The Sirepo GUI for MAD-X supports a wide range of features

- Beamline and lattice component construction
- Layard construction and deconstruction
- Variables and high level parameterization
- TWISS command support
- Matching support
- Templates and implementations for PTC
- Comparison tools for TWISS and PTC results
- Import and export of simulations using sequence files

The screenshot shows the MAD-X GUI interface for lattice construction. The main window displays a 3D visualization of a lattice section labeled 'Lattice - a2u'. Below it is the 'Beamline Editor - a2u' window, which contains a drag-and-drop area for defining the beamline. The right-hand side of the interface features two tables: 'Beamlines' and 'Beamline Elements'.

Name	Description	Elements	Start-End	Length	Bend
a2u	(ubegin,D2.270464,uxf1,D4.93344R01	48	161.5m	161.9m	12.3°

Name	Description	Length	Bend
^ DRIFT			
D1.0343482e01		10.34m	
D1.2455476e01		12.46m	
D1.291864R01		0.129m	
D1.3030333e01		13.03m	
D1.38583		1.386m	
D1.45424883E01		14.54m	
D1.524R01		0.152m	
D1.56896		1.568m	
D1.486		1.696m	
D1.780921e01		17.81m	
D2.11404R01		0.211m	

Top: Example lattice construction using MAD-X import. Here a sequence file is loaded for an existing lattice.

The screenshot shows the MAD-X GUI interface for lattice construction. The main window displays a 3D visualization of a lattice section labeled 'Lattice - arc'. Below it is the 'Beamline Editor - arc' window, which contains a drag-and-drop area for defining the beamline. The right-hand side of the interface features two tables: 'Beamlines' and 'Beamline Elements'.

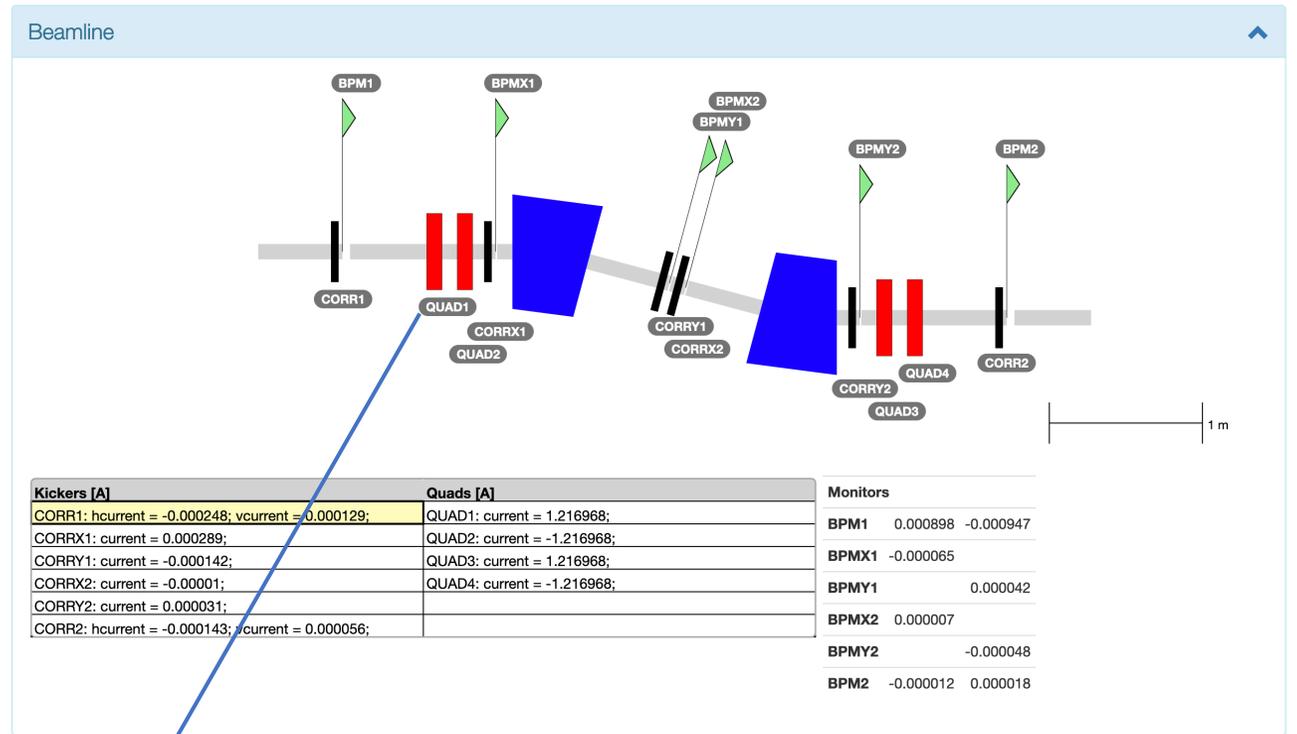
Name	Description	Elements	Start-End	Length	Bend
arc	(fodo,S1,fodo)	13	6.209m	6.300m	20.0°

Name	Description	Length	Bend
^ DRIFT			
D1		0.500m	
D2		0.100m	
^ KICKER			
K1		0	
^ MONITOR			
M2		0	
^ QUADRUPOLE			
DQ	k1=-2	0.100m	
FO	k1=2	0.100m	
^ SBEND			
S1		0.500m	20.0°

Left: Example lattice construction using MAD-x and component beamlines. Component beamlines are built via drag and drop of individual elements. These component beamlines can then be added to larger beamlines to build a full lattice.

Sample controls interface

- Build a lattice in MAD-X and use our controls application for optimization
 - Controls display is generated automatically
 - Provides scalar settings and readings
 - Magnet transfer maps can be specified via upload of a CSV file
- Beam steering programs available
 - Optimize the beam trajectory based on weighted desired beam positions
 - python optimization toolboxes and matrix based steering are implemented



Optimization Targets

Optimization Method: Nelder-Mead

Monitor Name	X [m]	Y [m]	Weight
BPM1	0	0	0.1
BPMX1	0		0.1
BPMY1		0	0.1
BPMX2	0		0.1
BPMY2		0	0.1
BPM2	0	0	0.1

Simulation Completed
Elapsed time: 00:00:18

Start New Simulation

Beam Settings

Main | Twiss | Position

Particle: Proton

Gamma: 7.84

QUADRUPOLE

Quadrupole

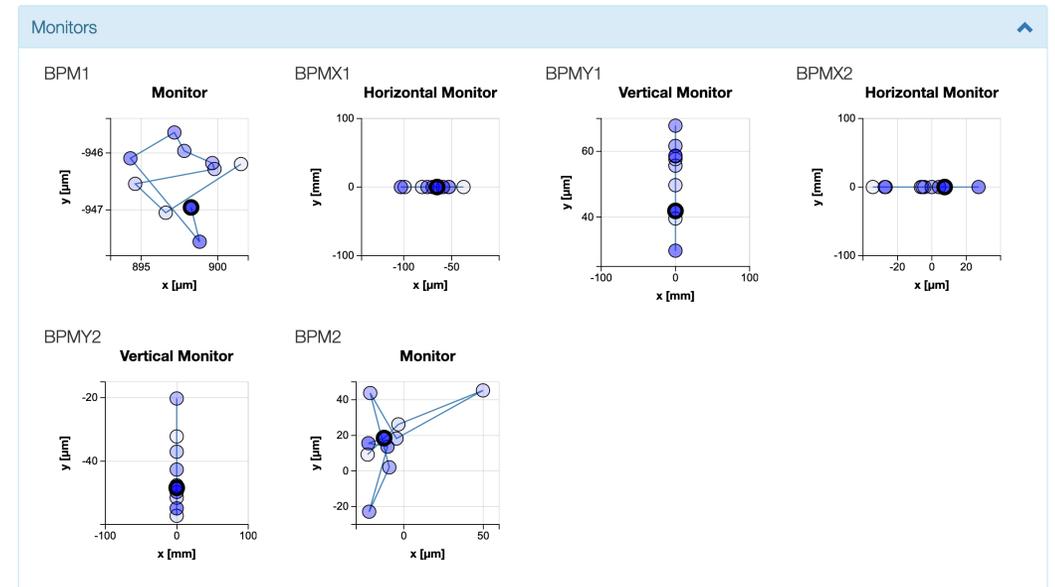
Name: QUAD2

Current [A]: -1.2169682896178346 K1 -5.000000

Amp Conversion Table (*.csv): K1 = $\frac{\text{current[A]} \cdot \text{charge[C]}}{\text{gamma.mass[kg]} \cdot \text{beta-c[m/s]}}$ · factor

Browse... No file selected.

Save Changes Cancel



Machine learning with Sirepo Activait

Activait Datasets Test with Input Data

Data Source

Application Mode: Data Analysis, Classification, Regression (checked)

Data File: test.csv

Inputs Scaler: Robust Scaler

Outputs Scaler: Robust Scaler

Columns

Column Name	Input	Output
11 y_rms	<input type="checkbox"/>	<input checked="" type="checkbox"/>
12 s_rms	<input type="checkbox"/>	<input checked="" type="checkbox"/>
13 px_rms	<input type="checkbox"/>	<input checked="" type="checkbox"/>
14 py_rms	<input type="checkbox"/>	<input checked="" type="checkbox"/>
15 ps_rms	<input type="checkbox"/>	<input checked="" type="checkbox"/>
16 emit_x	<input type="checkbox"/>	<input checked="" type="checkbox"/>
17 emit_y	<input type="checkbox"/>	<input checked="" type="checkbox"/>
18 emit_s	<input type="checkbox"/>	<input checked="" type="checkbox"/>
19 other	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Columns 11 - 19 of 19

Partition

Split Method: Random

Training %: 75

Testing %: 12.5

Validation %: 12.50

Input 1: Pregnancies

Input 2: Glucose

Input 3: Blood Pressure

Input 4: Skin Thickness

Layer: Densely Connected NN, Dimensionality: 20, Activation: Rectified Linear Unit (relu)

Layer: Gaussian Noise, Standard Deviation: 0.01

Layer: Densely Connected NN, Dimensionality: 10, Activation: Rectified Linear Unit (relu)

Layer: Gaussian Noise, Standard Deviation: 0.01

Layer: Densely Connected NN, Dimensionality: 20, Activation: Rectified Linear Unit (relu)

Layer: Gaussian Noise, Standard Deviation: 0.01

Layer: Densely Connected NN, Dimensionality: 10, Activation: Linear (identity)

Add Layer

Output Layer: Densely Connected NN, Dimensionality: 10, Activation: Linear (identity)

Save Changes Cancel

