Bayesian Learning with Sparse Data

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Classification of CRTS detections

Objective: Predict the nature of the object based on available information About 40 useful different observations may be found.

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delm12, "FirstDetection agnitude", "minus", "SecondDetection agnitude"
delm13, "FirstDetection_agnitude", "minus", "ThirdDetection agnitude"
delm14, "FirstDetection agnitude", "minus", "FourthDetection agnitude"
delm23, "SecondDetection agnitude", "minus", "ThirdDetection agnitude"
delm24, "SecondDetection agnitude", "minus", "FourthDetection agnitude"
delm34, "ThirdDetection agnitude", "minus", "FourthDetection agnitude"
cdml2, "catotFirstDetection agnitude", "minus", "catotSecondDetection agnitude"
cdml3, "catotFirstDetection agnitude", "minus", "catotThirdDetection agnitude"
cdm14, "catotFirstDetection agnitude", "minus", "catotFourthDetection agnitude"
cdm23, "catotSecondDetection agnitude", "minus", "catotThirdDetection agnitude"
cdm24, "catotSecondDetection agnitude", "minus", "catotFourthDetection agnitude"
cdm34, "catotThirdDetection_agnitude", "minus", "catotFourthDetection_agnitude"
gi, "pphotT gpr Magnitude", "minus", "pphotT ipr Magnitude"
gr, "pphotT gpr Magnitude", "minus", "pphotT rpr Magnitude"
gz, "pphotT gpr Magnitude", "minus", "pphotT zpr Magnitude"
ir, "pphotT_ipr__Magnitude", "minus", "pphotT_rpr__Magnitude"
iz, "pphotT_ipr__Magnitude", "minus", "pphotT_zpr__Magnitude"
rz, "pphotT_rpr__Magnitude", "minus", "pphotT zpr Magnitude"
csNusnoD, "cs nearest obj usnobdistance", "", ""
csNcgraD, "cs_nearest obj cgrabsdistance", " ", " "
csNcrateD, "cs nearest obj cratesdistance", "", ""
csNnedD, "cs nearest obj neddistance", "", ""
csNveroD, "cs_nearest_obj_verondistance", "", ""
csNsimbD, "cs_nearest_obj_simbaddistance", "", ""
csNnvssD, "cs nearest obj nvssdistance", "", ""
csNradioD, "cs nearest obj radiodistance", "", ""
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Skyalert portfolio

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0.021900999999997 0.017900999999984 -0.0040000000000134 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -
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Missing values

Class	Total Instances	Missing-Galaxydata	Missing-stardata	Missing-Both
1(CV)	437	376 (86.04%)	375(85.81%)	375 (85.81%)
2(SN)	546	379(69.41%)	387(70.87%)	377(69.04%)
3(OT)	19	11(57.89%)	11(57.89%)	11(57.89%)
5(BL)	202	151(74.75%)	151(74.75%)	151(74.75%)
6(AGN)	76	43(56.57%)	43(56.57%)	43(56.57%)
7(UVC)	46	43(93.47%)	43(93.47%)	43(93.47%)
9(VS)	64	57(89.06%)	57(89.06%)	57(89.06%)
10(MV)	9	9(100%)	9(100%)	9(100%)
Total	1399	1069(76.41%)	1076(76.91%)	1066(76.19%)

Most ML algorithms crash with so many missing entries.

Vasudha Bhatnagar, DU

How will we represent the data vector?

- How will we represent the data vector?
- How will we train the ML algorithm when most entries are missing?

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- How can we quantify the significance of each input feature?

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- How can we quantify the significance of each input feature?
- What algorithms can handle the scenario?
- How can we quantify the reliability of the predictions?

Data Representation

• The nature or class of the object is fixed. What changes is the available input to describe it.

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• The nature or class of the object is fixed. What changes is the available input to describe it.

- It was decided to use a binary genetic coding to represent the input vector.
- Each observation has a particular slot in the genetic chain/sequence. A 0 means missing.
- All events with the same genetic code have the same set of observations.
- New observations are appended to the right of the chain, reading from left to right.

Training on Missing Data

- With every input vector, also supply an input mask (genetic code for the input vector) so that the ML algorithm knows what to use for learning and what all is to be ignored.
- Each species vector is treated independently by the learning algorithm.
- Update the algorithm (for available inputs) such that the cost function is minimised.
- Test on new data with known nature to estimate the accuracy of the predictions.

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In, "Cataclysmic Variable"

22, "Supernova"

33, "other"

15, "Blazar Outburst"

60, "Active Galactic Nucleus Variability"

77, "UVCeti Variable"

89, "Variable"

10, "Mira Variable"

11, "High Proper Motion Star"

12, "Comet"

16, "Nova"
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. [1, "Cataclysmic Variable"
≥2,"Supernova"
                                Results (Training used 80% data)
33,"other"
15, "Blazar Outburst"
56,"Active Galactic Nucleus Variability"
37,"UVCeti Variable"
78. "Asteroid"
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33. "other"
15, "Blazar Outburst"
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6,"Active Galactic Nucleus Variability"
7, "UVCeti Variable"
8, "Asteroid"
39, "Variable"
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. [1, "Cataclysmic Variable"

22, "Supernova"

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33. "other"
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6, "Active Galactic Nucleus Variability"
7, "UVCeti Variable"
8, "Asteroid"
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                                                                                                                          0,
                                                                                                                                               3,
                                                                                                                                                         0,
                                                                                                                                                                  3,
                                                                                  0,
                                                                                                                                    0,
                               [16]
                                                                                            0.
                                                                                                      0.
                                                                                                                0.
                                                   0.
                                                             0.
                                                                        0,
                                                                                  0,
                                                                                                                          0.
                                                                                                                                    0.
                                                                                                                                               0.
                                                                                                                                                                   0,
                                                                                                                                                         0.
                               Total, 627,
                                                   767,
                                                             81,
                                                                       65,
                                                                                 171,
                                                                                                      4.
                                                                                                                                                                  1814
                                                                                            39,
                                                                                                                17,
                                                                                                                          4.
                                                                                                                                    36,
                                                                                                                                              3,
                                                                                                                                                        0,
```

. [1, "Cataclysmic Variable"

22, "Supernova"

Cross Validation

Real-> [1] Predict	. [2] .	[3] ′	[5] 、	[6] .	[7] .	[8] ,	[9] 、	[10].	[11] .	[12] .	[16]、	Total	Real-> Predict		[2] .	[3] .	[5] .	[6] .	[7] .	[8] .	[9] .	[10].	[11] .	[12] .	[16] .	Total
[1], 39,	12	2	0.	1,	2	0.	1,	2	1,	0.	0.	60,	[1].	29.	8,	2	4.	4.	0,	0,	1,	1,	2	0,	0.	51,
[2] . 16. [3] . 0.	55. 1,	8. 0.	1, 0,	5, Q,	O. O.	1, O,	2 0.	O. O.	4, 0,	1. Q	O. O.	93. 1.	(2-10)-21 DO	15. 1.	53, 2,	0. 3.	O. O.	10. 0.	2, 1,	2, 0,	1. Q	O. 1.	2 0.	O. O.	О. О.	85. 8.
[5] , 0, [6] , 6,	0, 6,	1, 3,	5. 3.	Q. 2Q.	O, 1,	O. O.	Q. Q.	Q. Q.	O. O.	O. O.	O. O.	6, 39,		0. 7.	Q. 1Q.	O. 1.	6. 6.	Q 13,	0. 4.	O. O.	O. 1.	1. Q.	O. O.	O. O.	O. O.	7. 42.
[7] . 0.	0,	O,	O,	O,	1,	0,	O,	O,	0,	0,	0.	1.	[7] .	0,	0,	0.	O.	O,	1,	Ο.	O,	O,	0.	0,	0.	1.
[8], 0, [9], 0,	Q. Q.	Q Q	O. O.	O, O	O. O.	Q. Q.	O, O,	O. O.	O. O.	O, O,	O. O.	Q. Q.		O. O.	O. O.	O. O.	O. O.	O, O,	O. O.	O, O,	O. O.	O, O,	O. O.	O. O.	O. O.	O. O.
[10] . Q [11] . Q	0.	Q. Q.	O. O.	Q. Q.	O. O.	O, O,	Q. Q.	O. O.	O. O.	O.	O. O.	Q. Q.		2. 0.	O. O.	O. O.	O. O.	O. O.	O. O.	O. O.	O. O.	O. O.	0. 5.	O. O.	O. O.	2 5.
[12] . 0.	Q. Q.	Q.	0,	O,	0.	0,	O,	0.	0,	O, O	0.	0.	[12].	O,	0.	0.	0,	O.	O.	Ο.	O.	O.	O.	0.	0.	O.
[16] . O. []	O,	Q.	O,	O,	0,	0,	O,	0,	O,	0,	O,	O,	[16] . []		0,	O,	0,	O,	0,	0,	Ο,	0,	O,	O,	O,	O,
Total, 61, Real->, [1] ,	74. [2] ,	14	9.	26,	4. [7] .	1, [8] ,	3 [0]	2	5.	1,	0,	200	Total		73.	6,	16.	27,	8,	2	3,	3,	9.	0.	0,	201
Predict.		[3] ,	[5] 、	[6] 、			[9] 、	[10] 、					l Real- Predi	ct.					[7] ,	[8] ,	[9] ,	[10].	[11] .	[12] .	[16] ,	Total
[1] , 24, [2] , 7,	12, 65,	2, 1,	2, 1,	3, 2,	1, 2	0. 2.	3, 1,	1, 1,	4. 2.	O. 1.	O, 1,	52, 86,	[1] . [2] .	31. 12.	10. 61.	O. 7.	1, 1,	3. 4.	1. 1.	Q. 1.	0. 2.	5. 0.	3, 10,	O. O.	O, 1,	54, 100,
[3] , 0, [5] , 1,	1. O.	O. O.	Q. 11,	Q. 1,	1. O.	O. O.	1. 1.	O.	1, Q	Q. Q.	O. O.	4. 14.	[3] 、 [5] 、		1, 0,	O. O.	0. 3.	1, 2,	O. O.	O. O.	O. O.	O. 1.	O. O.	O. O.	O, O,	2 6.
[6] , 7, [7] , Q	6. Q.	1. Q.	6,	15, Q	2 2	O. O.	1. Q.	O. O.	O. O.	O. O.	O. O.	38, 2,	[6] . [7] .	4.	7. 0.	3. 0.	4. 0.	11, Q	3, 1,	O. O.	O. O.	O. O.	O. O.	O. O.	O. O.	32 2
[8] . O.	0.	0.	0.	0.	0.	O. O.	0.	0. 0.	0.	0.	0,	0.	[8] . [9] .	0,	O. O.	Q. Q.	0. 0.	Ο,	0,	O. O.	Ο,	o. o.	Ο,	Ο,	Ο,	0.
[10] , 0,	0,	Ο,	1,	Ο,	Ο,	0,	1,	0,	0,	O,	0,	2	[10]	. 0.	0.	O,	0.	Q. Q.	O.	O.	O. O.	O,	O. O.	O. O.	O,	O.
[11] , Q [12] , Q	Q. Q.	Q. Q.	O. O.	Q. Q.	0. 0.	O. O.	O. O.	Q. Q.	2 0.	Q. Q.	O. O.	2, 0,	[12]	. O.	O. O.	O. O.	O. O.	O. O.	Q. Q.	O. O.	O. O.	O. O.	O. O.	O. O.	O. O.	O. O.
[16] , O, []	O,	0,	0,	0,	0,	0,	0,	0,	O,	O,	O,	0,	[16] []		O,	O,	O,	O,	O,	0,	O,	O,	O,	O,	0,	O,
Total 39	84,	4,	21,	21,	8.	2	8.	2	9.	1,	1,	200			79. [1] .	10,	9.	21, [5] , [6, 6], [7]	1, [8]	2 . [9]	6. [10].	13. [11] .	o. [12] ,	1, [16] ,	196 Total
eal-> [1] . redict.	[2] .	[3] .	[5] .	[6] .	[7] .	[8]	. [9]	. [1	.0] . [11].	[12] .	[16] .	Total	Predic												
1], 39, 2], 9,	9. 57.	O. O.	O. O.	13, 7,	2,	1, Q,	2, 1,	0		2 2	0. 2.	O. O.	68. 78.	[1] . [2] .	6. 6.	2 12	O. O.		1, 1, 2, 0,	0, 2,	Q. 1,	1. 0.	Q, Q,	Q. Q.	O, O,	11, 23,
3], 0,	1,	1,	O,	1,	O,	0.	0,	C).	0,	0,	O,	3,	[3] .	0,	0,	O,	0,	O, O,	0,	Q,	0,	O,	O,	O,	Q,
5], 1, 6], 4,	Q, 8,	0. 1.	7. 3.	2 12	O. O.	O, 1,	1. 2.	0		O. O.	O.	O, O,	11, 31,	[5]、 [6]、	Q. Q.	1, 0,	0, 1,		O, O, O, O,	Q. Q.	Q 1,	0. 0.	Q, Q,	Q, Q,	O,	2
7], 0,	0,	2	0,	O,	1.	0,	0,	0		0.	0,	0.	3.	[7].	0,	0.	0,	0,	O, O,	0,	O,	0,	0,	0,	0,	0.
8]. O. 9]. O.	Q. Q.	O. O.	O. O.	O. O.	O. O.	O, O,	O. O.	0		O, O,	O. O.	O, O,	O. O.	[8] . [9] .	Q Q	Q. Q.	O. O.		Q Q Q Q		Q Q	Q. Q.	Q, Q,	Q. Q.	Q, Q,	O. O.
10] , 1, 11] , 1,	O. O.	O. O.	O. O.	1. Q	O. O.	O. O.	0.	1		O. 1.	O. O.	O.	3. 2.	[10].	O,	0,	0,	0,	O, O,	0,	O,	O,	Q.	Q,	O,	0.
12] . 0.	O,	Ο,	0,	O,	0,	0.	0,	C).	0,	0,	0,	Ο,	[11] . [12] .		O. O.	O, O,		Q Q Q Q	Q, Q,	Q Q	O. O.	Q, Q,	Q. Q.	O, O,	O,
16], Q,]	O,	O,	O,	O,	O,	O,	O. 	C).	0,	0,	O,	Ο,	[16]、 []		0,	0,	0,	0, 0,	0,	Q.	0,	0,	0,	O,	0,
otal, 55	75.	4.	10,	36,	3,	2	6,	1		5,	2	O,	199	Total,	12	15,	1,	1,	3, 1,	2	_ 2	1,	0,	0,	0,	38

Continued Learning Model

Humans Learn from every experience. Let us replicate the same in machines too- Continued training and evaluation.

Advantages

- The learning will progress with time the key features required for correct identification will be exposed by the failing candidates – feed back.
- Prediction accuracy will asymptotically improve until the system replaces human expert.

Latest Status

Real-> [1].	[2] .	[3].	[5] .	[6] .	[7] . [[8] .	[9] .	[10] .	[11] .	[12] .	[16] .	Total		
Predict, [1] . 272 [2] . 4. [3] . 0.	4. 404. 1.	7. 4. 34.	1, Q, Q,	1, 4, 0,	O. 1. O.	1, 3, 0,	4. 2. 0.	3, 0, 0,	2 2 0.	O. 1. O.	1, Q, Q,	296, 425, 35,		
[5] . 0.	0.	1.	60	0.	0.	0.	0.	1.	0.	0.	0.	62		
[6] . 1. [7] . O.	O. O.	O. O.	1, O,	126, 0,	0, 32,	O. O.	O. O.	O. O.	O. O.	O. O.	O. O.	128, 32,		
[8] . 0.	0.	0.	0.	0.	0.	6.	0.	0.	O.	O.	0.	6.		
[9], 0,	0,	Ο,	Ο,	0,	Ο,	Ο,	18,	Ο,	O,	O,	Ο,	18.		
[10] . 0.	0.	0.	O.	Ο.	O.	O.	0.	12	O.	O.	0.	12		
[11] . 0.	Ο.	0.	O.	0.	O.	O.	0.	O.	44.	O.	0.	44.		
[12] . 0.	0.	0.	0.	0.	0.	0.	0.	0.	O.	5.	0.	5.		
[16], O, []	O.	O.	Ο,	Ο,	Ο,	Ο.	O.	O,	O,	O,	1.	1,		
Total 277.	409,	46,	62,	131,	33,	10,	24.	16.	48.	6,	2	1064		
*	Pre [1] [2] [3] [5] [6] [7] [8] [10 [11 [12 [16	. Q . Q . Q . Q . Q . Q] . Q	39, 0, 1776 0, 0, 0, 0, 0, 0, 0, 0,	268, Q, Q, Q, Q, Q, Q, Q,	0. 0. 94. 0. 0. 0. 0. 0. 0. 0.	[6] . Q. Q. Q. GO3. Q. Q. Q. Q. Q. Q. Q. Q. Q.	0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	[8] 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0	0. 0. 0. 0. 0. 24. 0. 0.	0. 0. 0. 0. 0. 23. 0. 0.	0. 0. 0. 0. 0. 0. 0. 67. 0.	0. 0. 0. 0. 0. 0. 0. 14. 0.	[16] . Q Q Q Q Q Q Q Q Q Q Q Q Q Q Q Q Q Q	Total 1589, 1776, 268, 94, 603, 83, 8, 24, 23, 67, 14,
	Tot	al 1589	9. 1776	268	94,	603,	83,	8,	24,	23,	67.	14,	1,	4550
*Total	S	ucce	ss in	Su	cces	s in	Νo	n cl	assi	fied	Re	al su	ccess	in
* No.	Ιs	t Ch	oice	2nd	Choi	ce	it	ems			two	chan	ces	
* 1092 *		10	19		3			2 0			9	95.335	3 %	
•														