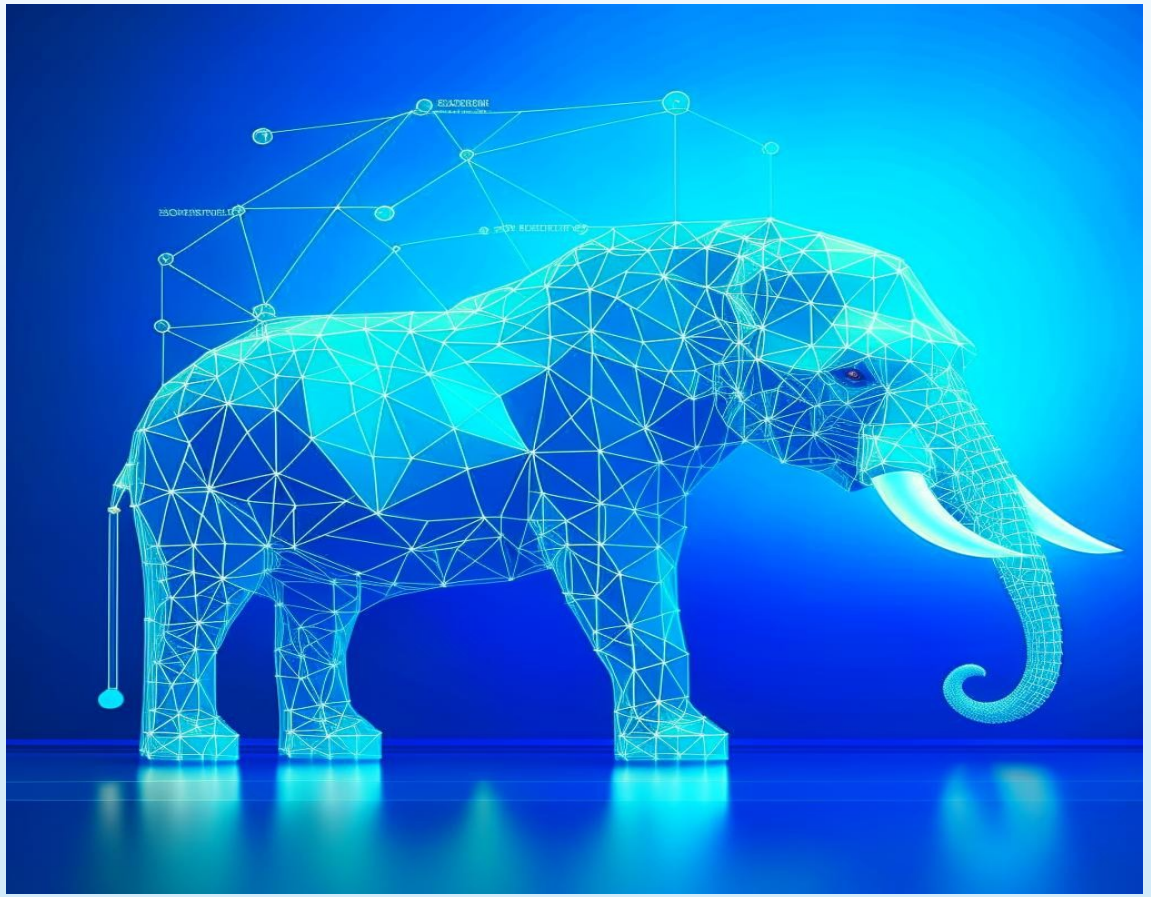
ML in PostgreSQL



Using models:

- Binary Classification
- Multi Classification
- Regression

Using framework:

CatBoost: https://catboost.ai/

only prediction

ML process:

1. Training model
2. Save model to database server
3. prediction

```
model.save_model('astra.cbm')
!ls
```

```
astra.cbm  astra.json  catboost_i
```

```
adult=# SELECT ml_predict ('astra3.cbm','astra3');
WARNING:  field run_id not used
WARNING:  field field_id not used
WARNING:  field spec_obj_id not used
WARNING:  field predict not used
      ml_predict
-----------------------
 public.astra3_predict
(1 row)
```

Installation

- git clone https://github.com/akalend/pg_ml.git
- export PG_HOME=/usr/local/pgsql //where is main postgres folder
- wget https://github.com/catboost/catboost/releases/download/v1.2.2/libcatboostmodel.so
- mv libcatboostmodel.so $PG_HOME/lib
- cd pg_ml
- export PG_CONFIG=$PG_HOME/bin/pg_config
- export LD_LIBRARY_PATH=$PG_HOME/lib
- USE_PGXS=1 make
- sudo su
- export PATH=$PATH:$PG_HOME/bin
- USE_PGXS=1 make install
- chown postgres model.cbm
- [optional] cp model.cbm $PG_HOME/data

Configuration

postgresql.conf:

```
# path to model folder
ml.model_path = /usr/local/model
```

DataFrame columns convert to PostgreSQL fields

ID, Id, id

FieldID, Field_ID

Import-port

Port, PORT

<=>

id

field_id

import_port

port

DataFrame columns and PostgreSQL fields

```
[14] df = pd.read_csv('star_classification.csv')
```

```
[16] for it in df.columns:
       print(it)

     obj_ID
     alpha
     delta
     u
     g
     r
     i
     z
     run_ID
     rerun_ID
     cam_col
     field_ID
     spec_obj_ID
     class
     redshift
     plate
     MJD
     fiber_ID
```

<=>

```
adult=# \d astra3
                    Table "public.astra3
   Column    |        Type        | Collation
-------------+--------------------+-----------
 alpha       | double precision   |
 delta       | double precision   |
 u           | double precision   |
 g           | double precision   |
 r           | double precision   |
 i           | double precision   |
 z           | double precision   |
 run_id      | bigint             |
 cam_col     | bigint             |
 field_id    | bigint             |
 spec_obj_id | double precision   |
 redshift    | double precision   |
 plate       | bigint             |
 mjd         | bigint             |
 fiber_id    | bigint             |

adult=#
```

DataFrame columns and PostgreSQL fields

```
df.head()
```

	obj_ID	alpha	delta	u	g	r	i	z	run_ID	rerun_ID	cam_col	field_ID	spec_obj_ID
0	1.237661e+18	135.689107	32.494632	23.87882	22.27530	20.39501	19.16573	18.79371	3606	301	2	79	6.543777e+18
1	1.237665e+18	144.826101	31.274185	24.77759	22.83188	22.58444	21.16812	21.61427	4518	301	5	119	1.176014e+19
2	1.237661e+18	142.188790	35.582444	25.26307	22.66389	20.60976	19.34857	18.94827	3606	301	2	120	5.152200e+18
3	1.237663e+18	338.741038	-0.402828	22.13682	23.77656	21.61162	20.50454	19.25010	4192	301	3	214	1.030107e+19
4	1.237680e+18	345.282593	21.183866	19.43718	17.58028	16.49747	15.97711	15.54461	8102	301	3	137	6.891865e+18

```
adult=#  select * from astra3 limit 3;
      alpha       |      delta       |    u     |    g     |    r     |    i     |    z     | run_id | cam_col | field_id |      spec_obj_id
------------------+------------------+----------+----------+----------+----------+----------+--------+---------+----------+-----------------------
 16.9568897845004 | 3.64613008870454 | 23.33542 | 21.95143 | 20.48149 |   19.603 | 19.13094 |   7712 |       6 |      442 |  4.855016555329904e+18
 240.063240247767 | 6.13413059813973 | 17.86033 | 16.79228 | 16.43001 | 16.30923 | 16.25873 |   3894 |       1 |      243 | 2.4489280322708705e+18
  30.887222067625 | 1.18870964120799 | 18.18911 | 16.89469 | 16.42161 | 16.24627 | 16.18549 |   7717 |       1 |      536 |  8.255357438959835e+18
(3 rows)
```

Information about model

```
adult=# SELECT ml_info ('astra3.cbm');
                                        ml_info
-------------------------------------------------------------------------------
 dimension:3 numeric features:12 categorial features:0 modelType "MultiClass"+
 fieldName:alpha,delta,u,g,r,i,z,cam_col,redshift,plate,MJD,fiber_ID
(1 row)

adult=#
```

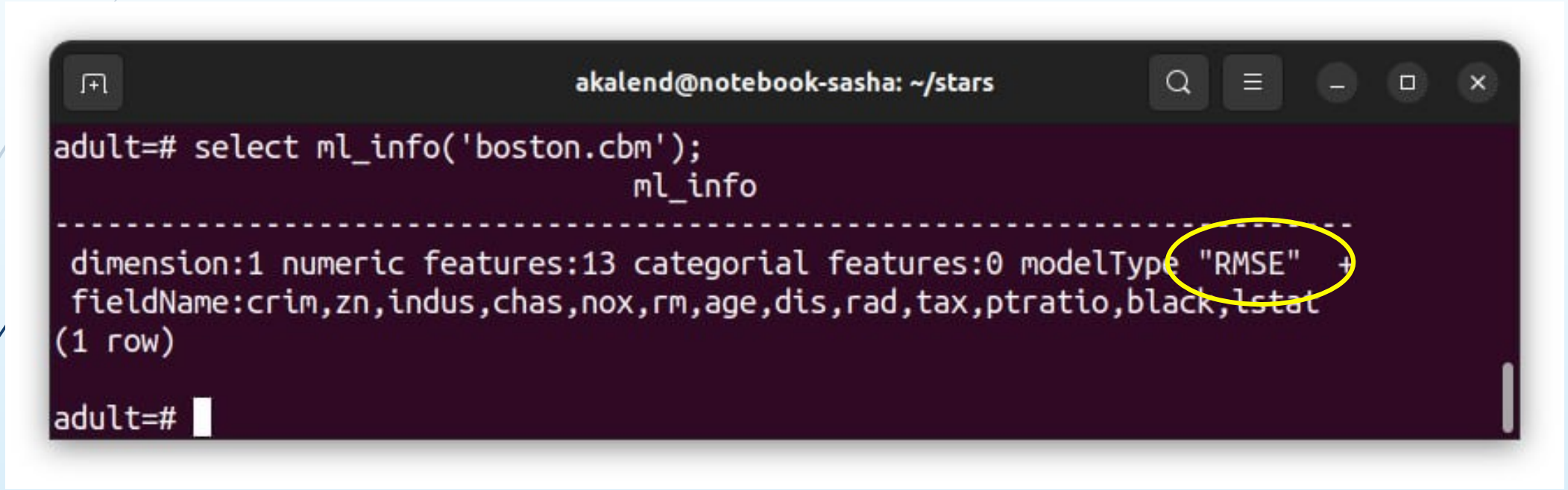
- Dimension result (How many classes)
- Feature count (categorical and float)
- Type of model
- Fields name

Information about model

```
adult=# SELECT ml_info ('astra3.cbm');
                                        ml_info
-------------------------------------------------------------------------------
 dimension:3 numeric features:12 categorial features:0 modelType "MultiClass"+
 fieldName:alpha,delta,u,g,r,i,z,cam_col,redshift,plate,MJD,fiber_ID
(1 row)

adult=#
```

```
adult=# SELECT ml_info ('titanic.cbm');
                                        ml_info
-------------------------------------------------------------------------------
 dimension:1 numeric features:2 categorial features:9 modelType "Accuracy"      +
 fieldName:PassengerId,Pclass,Name,Sex,Age,SibSp,Parch,Ticket,Fare,Cabin,Embarked
(1 row)
```

Model information



More information

```
model.save_model('astra.json', format='json')
!ls
```

```
astra.cbm  astra.json  catboost_info  sample_data
```

```
adult=# SELECT * from  ml_json_info('astra.json');
                              ml_json_info
-----------------------------------------------------------------------------
 float feature:alpha,delta,u,g,r,i,z,cam_col,redshift,plate,MJD,fiber_ID,+
 categorial feature:
(1 row)
```

Categorical Feature list
Float Feature count list

Prediction of model (recordset)

Path to model file

Table name

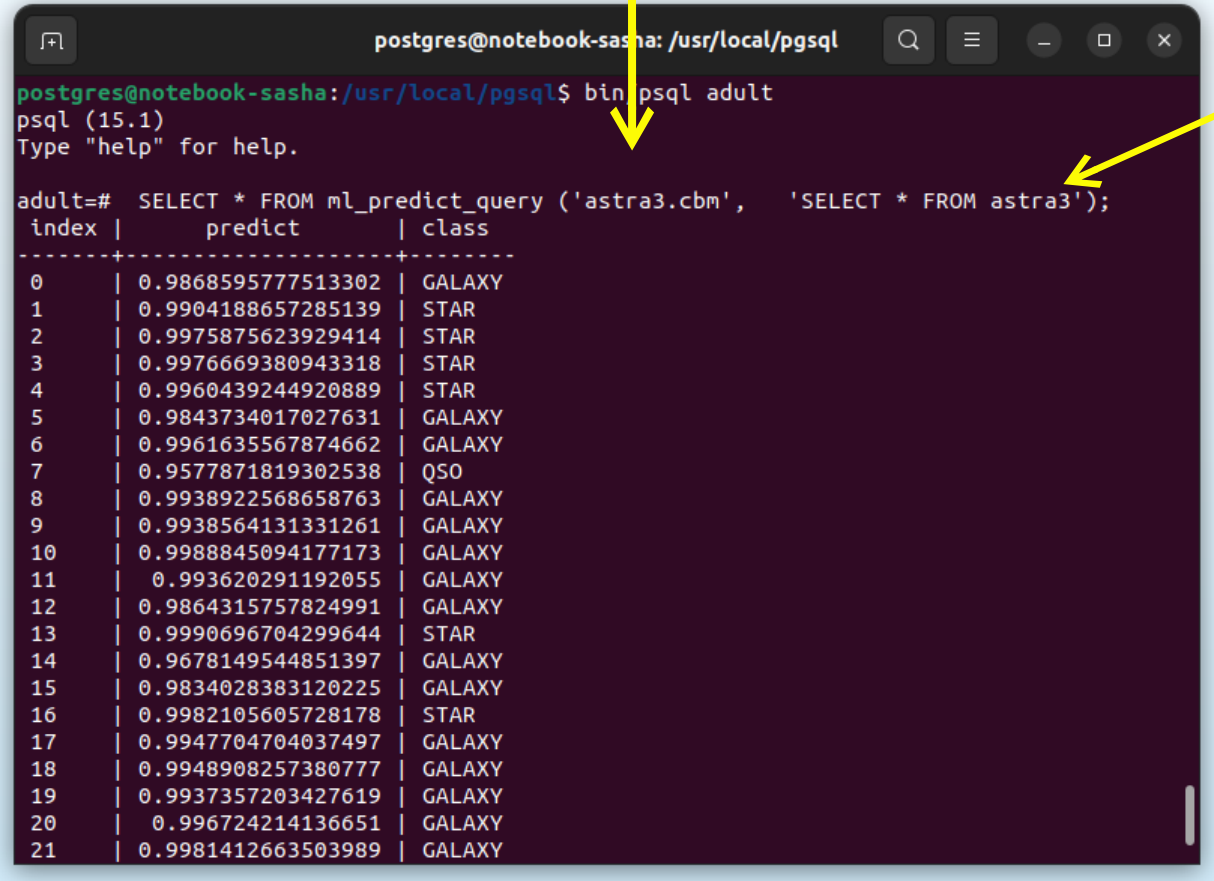
Categorical field list

```
adult=#   SELECT * from ml_cat_predict ('titanic.cbm',
'titanic','{name,passenger_id,pclass,sex,sibsp,parch,ticke
t,cabin,embarked }');
 row_num |        predict        | class
---------+-----------------------+-------
       0 |   -1.7937342449233795 | 0
       1 |   -0.7958399022225136 | 0
       2 |    -2.392873216013247 | 0
       3 |    -1.942976624899004 | 0
       4 |  -0.41747860726736713 | 0
       5 |   -2.0608914711097546 | 0
       6 |    0.5914467057444344 | 1
       7 |   -1.0786526230973736 | 0
       8 |    0.6757411102494171 | 1
       9 |    -3.250956928980716 | 0
      10 |    -2.274725588104562 | 0
      11 |   -1.3228896775643357 | 0
      12 |      2.70931909246417 | 1
      13 |   -2.4233542239140187 | 0
```

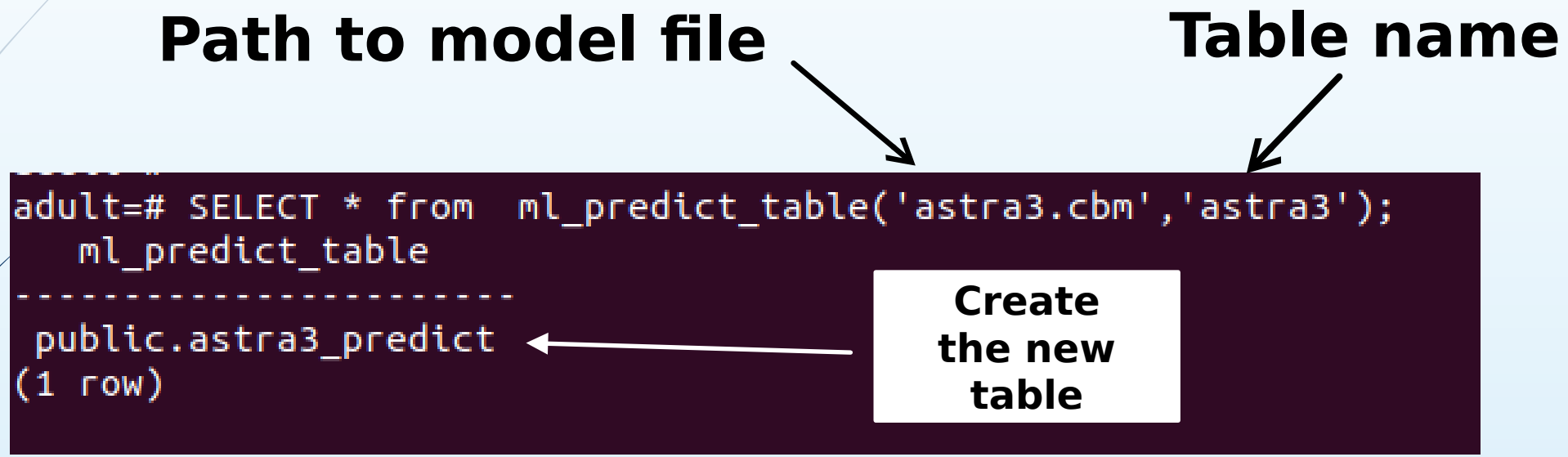
Prediction of model (query)

Path to model file

query



Prediction of model (result table)

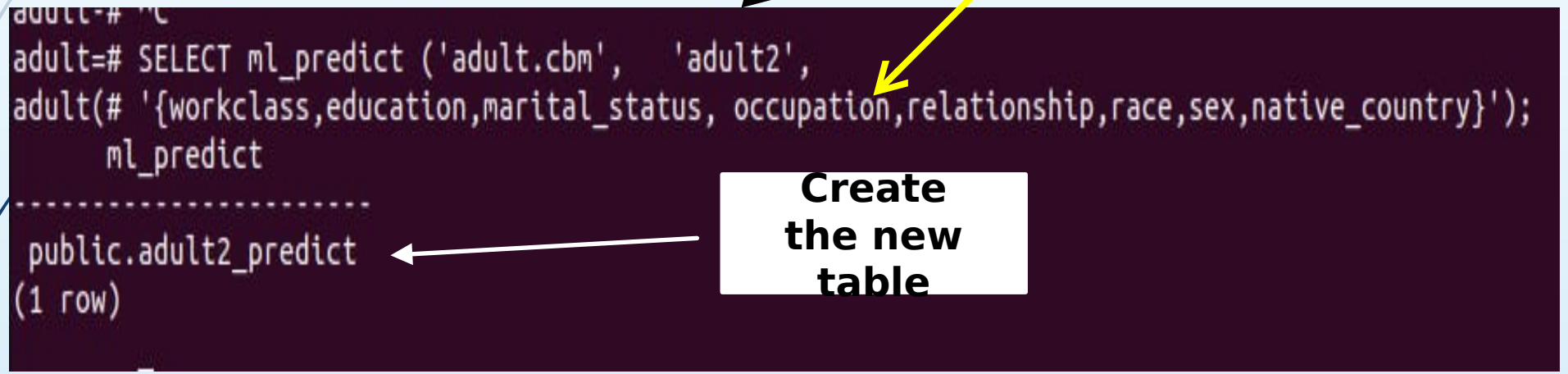


Prediction of model (table)

Path to model file

Table name

List of categorical fields



Prediction results

SELECT * FROM {table}_predict;

```
adult=# SELECT * from astra3_predict;
 row |       alpha       |       delta       |    u    |    g    |    r    |    i    |    z    | run_id | cam_col | field_id |      spec_obj_id      |   redshift   | plate |  mjd  | fiber_id | predict | class
-----+-------------------+-------------------+---------+---------+---------+---------+---------+--------+---------+----------+-----------------------+--------------+-------+-------+----------+---------+--------
   1 |  16.9568897845004 |  3.64613008870454 | 23.33542 | 21.95143 | 20.48149 |  19.603 | 19.13094 |   7712 |       6 |      442 | 4.855016555329904e+18 |    0.5062369 |  4312 | 55511 |      495 | 0.98686 | GALAXY
   2 |  240.063240247767 |  6.13413059813973 | 17.86033 | 16.79228 | 16.43001 | 16.30923 | 16.25873 |   3894 |       1 |      243 | 2.448928032270870e+18 | 0.0003448142 |  2175 | 54612 |      348 | 0.990419 | STAR
   3 |   30.887222067625 |  1.18870964120799 | 18.18911 | 16.89469 | 16.42161 | 16.24627 | 16.18549 |   7717 |       1 |      536 | 8.255357438959835e+18 | 4.085216e-06 |  7332 | 56683 |      943 | 0.997588 | STAR
   4 |  247.594400505002 |  10.8877797153666 | 24.99961 | 21.71203 | 21.47148 | 21.30532 | 21.29109 |   5323 |       1 |      134 | 4.577998722756271e+18 | -0.0002914838 |  4066 | 55444 |      326 | 0.997667 | STAR
   5 |  18.8964507920807 | -5.26133022886992 | 23.76648 | 21.79737 | 20.69543 | 20.23403 | 19.97464 |   7881 |       3 |      148 |  8.9104717664278e+18 | -0.0001361561 |  7914 | 57331 |      363 | 0.996044 | STAR
   6 |  182.713733094955 |  51.3758050594777 | 22.44608 | 21.68444 | 20.24292 | 19.41423 | 19.08227 |   2830 |       1 |      411 | 7.516725588574623e+18 |    0.5026683 |  6676 | 56389 |      792 | 0.984373 | GALAXY
   7 |  150.089423193165 |  39.4670880748061 | 18.96441 | 17.82906 | 17.31429 | 16.99891 | 16.85583 |   3560 |       4 |      278 | 1.526795641110423e+18 |  0.06366445 |  1356 | 53033 |      274 | 0.996164 | GALAXY
   8 |  189.510984338851 |  58.7411197772507 | 21.37376 | 20.80187 | 20.84925 | 21.13449 | 20.34689 |   2243 |       1 |      353 |  7.696817897528907e+18 |    0.7936153 |  6836 | 56443 |      604 | 0.957787 | QSO
   9 |  37.7138728560977 | -0.525138228146508 | 20.77988 | 19.54618 | 19.16687 | 18.89438 | 18.64286 |   2700 |       2 |      117 | 1.755328123029217e+18 |    0.1060118 |  1559 | 53271 |      183 | 0.993892 | GALAXY
  10 |  201.074980072746 |  28.7699058867715 | 25.05349 | 22.23362 |  20.8122 | 19.69488 | 19.28336 |   4649 |       3 |      120 |  7.306035245308205e+18 |     0.567082 |  6489 | 56329 |      257 | 0.993856 | GALAXY
  11 |  151.8309183267 2 |  19.8108624669417 | 24.04443 | 22.48608 | 20.59701 | 19.50985 | 19.00457 |   5183 |       5 |      142 | 6.622787444780849e+18 |    0.5475619 |  5882 | 56029 |      888 | 0.998885 | GALAXY
```

SELECT * FROM ml_predict(...);

```
adult=# SELECT * from  ml_predict('astra3.cbm'
'astra3');
 id  |      predict       | class
-----+--------------------+--------
   0 | 0.9868595777513302 | GALAXY
   1 | 0.9904188657285139 | STAR
   2 | 0.9975875623929414 | STAR
   3 | 0.9976669380943318 | STAR
   4 | 0.9960439244920889 | STAR
   5 | 0.9843734017027631 | GALAXY
   6 | 0.9961635567874662 | GALAXY
   7 | 0.9577871819302538 | QSO
   8 | 0.9938922568658763 | GALAXY
   9 | 0.9938564131331261 | GALAXY
```

Binary classification

postgres@notebook-sasha: /usr/local/pgsql

```
adult=# select * from titanic_predict;
 row | id  | passenger_id | pclass |                    name                    |  sex   | age  | sibsp | parch |      ticket      |   fare   |    cabin     | embarked | res |  predict  | clas
s
-----+-----+--------------+--------+--------------------------------------------+--------+------+-------+-------+------------------+----------+--------------+----------+-----+-----------+-----
--
   1 |   0 |          892 |      3 | Kelly, Mr. James                           | male   | 34.5 |     0 |     0 | 330911           |   7.8292 | -999         | Q        | f   |  0.142616 | 0
   2 |   1 |          893 |      3 | Wilkes, Mrs. James (Ellen Needs)           | female |   47 |     1 |     0 | 363272           |        7 | -999         | S        | f   |  0.310916 | 0
   3 |   2 |          894 |      2 | Myles, Mr. Thomas Francis                  | male   |   62 |     0 |     0 | 240276           |   9.6875 | -999         | Q        | f   |  0.083718 | 0
   4 |   3 |          895 |      3 | Wirz, Mr. Albert                           | male   |   27 |     0 |     0 | 315154           |   8.6625 | -999         | S        | f   |  0.125321 | 0
   5 |   4 |          896 |      3 | Hirvonen, Mrs. Alexander (Helga E Lindqvist) | female |   22 |     1 |     1 | 3101298          |  12.2875 | -999         | S        | f   |   0.39712 | 0
   6 |   5 |          897 |      3 | Svensson, Mr. Johan Cervin                 | male   |   14 |     0 |     0 | 7538             |    9.225 | -999         | S        | f   |  0.112956 | 0
   7 |   6 |          898 |      3 | Connolly, Miss. Kate                       | female |   30 |     0 |     0 | 330972           |   7.6292 | -999         | Q        | t   |  0.643697 | 1
   8 |   7 |          899 |      2 | Caldwell, Mr. Albert Francis               | male   |   26 |     1 |     1 | 248738           |       29 | -999         | S        | f   |  0.253761 | 0
   9 |   8 |          900 |      3 | Abrahim, Mrs. Joseph (Sophie Halaut Easu)  | female |   18 |     0 |     0 | 2657             |   7.2292 | -999         | C        | t   |  0.662787 | 1
  10 |   9 |          901 |      3 | Davies, Mr. John Samuel                    | male   |   21 |     2 |     0 | A/4 48871        |    24.15 | -999         | S        | f   |  0.037293 | 0
  11 |  10 |          902 |      3 | Ilieff, Mr. Ylio                           | male   | -999 |     0 |     0 | 349220           |   7.8958 | -999         | S        | f   |  0.093238 | 0
  12 |  11 |          903 |      1 | Jones, Mr. Charles Cresson                 | male   |   46 |     0 |     0 | 694              |       26 | -999         | S        | f   |  0.210338 | 0
```

```
adult=#   SELECT * from ml_cat_predict ('titanic.cbm',    'titanic','{name,passenger
_id,pclass,sex,sibsp,parch,ticket,cabin,embarked }');
 row_num |        predict         | class
---------+------------------------+-------
       0 |   -1.7937342449233795 | 0
       1 |   -0.7958399022225136 | 0
       2 |    -2.392873216013247 | 0
       3 |    -1.942976624899004 | 0
       4 |  -0.41747860726736713 | 0
       5 |   -2.0608914711097546 | 0
       6 |    0.5914467057444344 | 1
       7 |   -1.078832023973738 | 0
```

Binary classification

```
adult=# SELECT * FROM ml_cat_predict ('adult.cbm',   'adult2','{workclass,
education,marital_status, occupation,relationship,race,sex,native_country}
');
 row_num |       predict        | class
---------+----------------------+-------
       0 |  -5.926338548423682  | <=50K
       1 |  -1.225876230403332  | <=50K
       2 | -0.7485117670534811  | <=50K
       3 |  3.6351647093731705  | >50K
       4 |  -4.644606242153101  | <=50K
       5 |  -5.342578732065899  | <=50K
       6 | -3.9224526779262296  | <=50K
```

postgres@notebook-sasha: /usr/local/pgsql

row	age	workclass	fnlwgt	education	education_num	marital_status	occupation	relationship	race	sex	capital_gain	capital_loss	hours_per_week	native_country	predict	class
1	25	Private	226802	11th	7	Never-married	Machine-op-inspct	Own-child	Black	Male	0	0	40	United-States	0.002661	<=50K
2	38	Private	89814	HS-grad	9	Married-civ-spouse	Farming-fishing	Husband	White	Male	0	0	50	United-States	0.226904	<=50K
3	28	Local-gov	336951	Assoc-acdm	12	Married-civ-spouse	Protective-serv	Husband	White	Male	0	0	40	United-States	0.321146	<=50K
4	44	Private	160323	Some-college	10	Married-civ-spouse	Machine-op-inspct	Husband	Black	Male	7688	0	40	United-States	0.974298	>50K
5	18	nan	103497	Some-college	10	Never-married	nan	Own-child	White	Female	0	0	30	United-States	0.009522	<=50K
6	34	Private	198693	10th	6	Never-married	Other-service	Not-in-family	White	Male	0	0	30	United-States	0.004761	<=50K
7	29	nan	227026	HS-grad	9	Never-married	nan	Unmarried	Black	Male	0	0	40	United-States	0.019408	<=50K
8	63	Self-emp-not-inc	104626	Prof-school	15	Married-civ-spouse	Prof-specialty	Husband	White	Male	3103	0	32	United-States	0.560734	>50K
9	24	Private	369667	Some-college	10	Never-married	Other-service	Unmarried	White	Female	0	0	40	United-States	0.003572	<=50K
10	55	Private	104996	7th-8th	4	Married-civ-spouse	Craft-repair	Husband	White	Male	0	0	10	United-States	0.092036	<=50K
11	65	Private	184454	HS-grad	9	Married-civ-spouse	Machine-op-inspct	Husband	White	Male	6418	0	40	United-States	0.759614	>50K
12	36	Federal-gov	212465	Bachelors	13	Married-civ-spouse	Adm-clerical	Husband	White	Male	0	0	40	United-States	0.64466	>50K
13	26	Private	82091	HS-grad	9	Never-married	Adm-clerical	Not-in-family	White	Female	0	0	39	United-States	0.007208	<=50K
14	58	nan	299831	HS-grad	9	Married-civ-spouse	nan	Husband	White	Male	0	0	35	United-States	0.432042	<=50K

--Далее--

Regression

akalend@notebook-sasha: ~/stars

row	index	crim	zn	indus	chas	nox	rm	age	dis	rad	tax	ptratio	black	lstat	medv	predict
1	0	0.00632	18	2.31	0	0.538	6.575	65.2	4.09	1	296	15.3	396.9	4.98	24	24.99982
2	1	0.02731	0	7.07	0	0.469	6.421	78.9	4.9671	2	242	17.8	396.9	9.14	21.6	20.664359
3	2	0.02729	0	7.07	0	0.469	7.185	61.1	4.9671	2	242	17.8	392.83	4.03	34.7	33.677379
4	3	0.03237	0	2.18	0	0.458	6.998	45.8	6.0622	3	222	18.7	394.63	2.94	33.4	34.289002
5	4	0.06905	0	2.18	0	0.458	7.147	54.2	6.0622	3	222	18.7	396.9	5.33	36.2	34.615708
6	5	0.02985	0	2.18	0	0.458	6.43	58.7	6.0622	3	222	18.7	394.12	5.21	28.7	27.968317
7	6	0.08829	12.5	7.87	0	0.524	6.012	66.6	5.5605	5	311	15.2	395.6	12.43	22.9	21.682186
8	7	0.14455	12.5	7.87	0	0.524	6.172	96.1	5.9505	5	311	15.2	396.9	19.15	27.1	22.853984
9	8	0.21124	12.5	7.87	0	0.524	5.631	100	6.0821	5	311	15.2	386.63	29.93	16.5	17.011092
10	9	0.17004	12.5	7.87	0	0.524	6.004	85.9	6.5921	5	311	15.2	386.71	17.1	18.9	18.24062
11	10	0.22489	12.5	7.87	0	0.524	6.377	94.3	6.3467	5	311	15.2	392.52	20.45	15	17.543837
12	11	0.11747	12.5	7.87	0	0.524	6.009	82.9	6.2267	5	311	15.2	396.9	13.27	18.9	19.974764
13	12	0.09378	12.5	7.87	0	0.524	5.889	39	5.4509	5	311	15.2	390.5	15.71	21.7	20.70866
14	13	0.62976	0	8.14	0	0.538	5.949	61.8	4.7075	4	307	21	396.9	8.26	20.4	20.202922
15	14	0.63796	0	8.14	0	0.538	6.096	84.5	4.4619	4	307	21	380.02	10.26	18.2	18.175456
16	15	0.62739	0	8.14	0	0.538	5.834	56.5	4.4986	4	307	21	395.62	8.47	19.9	19.698336
17	16	1.05393	0	8.14	0	0.538	5.935	29.3	4.4986	4	307	21	386.85	6.58	23.1	22.304514
18	17	0.7842	0	8.14	0	0.538	5.99	81.7	4.2579	4	307	21	386.75	14.67	17.5	17.160698
19	18	0.80271	0	8.14	0	0.538	5.456	36.6	3.7965	4	307	21	288.99	11.69	20.2	18.706903
20	19	0.7258	0	8.14	0	0.538	5.727	69.5	3.7965	4	307	21	390.95	11.28	18.2	18.769804
21	20	1.25179	0	8.14	0	0.538	5.57	98.1	3.7979	4	307	21	376.57	21.02	13.6	13.985032

--Далее--

```
adult=#   SELECT * from ml_cat_predict ('boston.cbm',  'boston2');
 row_num |      predict       | class
---------+--------------------+-------
       0 |  24.99982028068538 |
       1 | 20.664358727562394 |
       2 |  33.67737911788664 |
       3 |  34.28900239364565 |
       4 |  34.61570849423551 |
       5 | 27.968317495475695 |
       6 |  21.68218578618033 |
```

Multi classification

```
adult=# SELECT * from astra3_predict;
 row |      alpha       |       delta       |    u     |    g     |    r     |    i     |    z     | run_id | cam_col | field_id |      spec_obj_id       |   redshift    | plate | mjd | fiber_id |  predict  | class
-----+------------------+-------------------+----------+----------+----------+----------+----------+--------+---------+----------+------------------------+---------------+-------+-----+----------+-----------+--------
   1 | 16.9568897845004 |  3.64613008870454 | 23.33542 | 21.95143 | 20.48149 |   19.603 | 19.13094 |   7712 |       6 |      442 | 4.855016555329904e+18  |  0.5062369    |  4312 | 55511 |      495 |  0.98686  | GALAXY
   2 | 240.063240247767 |  6.13413059813973 | 17.86033 | 16.79228 | 16.43001 | 16.30923 | 16.25873 |   3894 |       1 |      243 | 2.4489280322708705e+18 | 0.0003448142  |  2175 | 54612 |      348 |  0.990419 | STAR
   3 |  30.887222067625 |  1.18870964120799 | 18.18911 | 16.89469 | 16.42161 | 16.24627 | 16.18549 |   7717 |       1 |      536 | 8.255357438959835e+18  | 4.085216e-06  |  7332 | 56683 |      943 |  0.997588 | STAR
   4 | 247.594400505002 | 10.8877797153666  | 24.99961 | 21.71203 | 21.47148 | 21.30532 | 21.29109 |   5323 |       1 |      134 | 4.577998722756271e+18  | -0.0002914838 |  4066 | 55444 |      326 |  0.997667 | STAR
   5 | 18.8964507920807 | -5.26133022886992 | 23.76648 | 21.79737 | 20.69543 | 20.23403 | 19.97464 |   7881 |       3 |      148 | 8.91047176642785e+18   | -0.0001361561 |  7914 | 57331 |      363 |  0.996044 | STAR
   6 | 182.713733094955 |  51.3758050594777 | 22.44608 | 21.68444 | 20.24292 | 19.41423 | 19.08227 |   2830 |       1 |      411 | 7.51672558857462 3e+18 |  0.5026683    |  6676 | 56389 |      792 |  0.984373 | GALAXY
   7 | 150.089423193165 |  39.4670880748061 | 18.96441 | 17.82906 | 17.31429 | 16.99891 | 16.85583 |   3560 |       4 |      278 | 1.526795641110423 6e+18 |  0.06366445   |  1356 | 53033 |      274 |  0.996164 | GALAXY
   8 | 189.510984338851 |  58.7411197772507 | 21.37376 | 20.80187 | 20.84925 | 21.13449 | 20.34689 |   2243 |       1 |      353 | 7.696817897528907e+18  |  0.7936153    |  6836 | 56443 |      604 |  0.957787 | QSO
   9 | 37.7138728560977 | -0.525138228146508 | 20.77988 | 19.54618 | 19.16687 | 18.89438 | 18.64286 |   2700 |       2 |      117 | 1.755328312302921 7e+18 |  0.1060118    |  1559 | 53271 |      183 |  0.993892 | GALAXY
  10 | 201.074980072746 |  28.7699058867715 | 25.05349 | 22.23362 |  20.8122 | 19.69488 | 19.28336 |   4649 |       3 |      120 | 7.306035245308205e+18  |  0.567082     |  6489 | 56329 |      257 |  0.993856 | GALAXY
  11 | 151.8309183267 2 | 19.8108624669417  | 24.04443 | 22.48608 | 20.59701 | 19.50985 | 19.00457 |   5183 |       5 |      142 | 6.622787444780849e+18  |  0.5475619    |  5882 | 56029 |      888 |  0.998885 | GALAXY
```

```
adult=# SELECT * from  ml_predict('astra3.cbm'
'astra3');
 id |      predict       | class
----+--------------------+--------
  0 | 0.9868595777513302 | GALAXY
  1 | 0.9904188657285139 | STAR
  2 | 0.9975875623929414 | STAR
  3 | 0.9976669380943318 | STAR
  4 | 0.9960439244920889 | STAR
  5 | 0.9843734017027631 | GALAXY
  6 | 0.9961635567874662 | GALAXY
  7 | 0.9577871819302538 | QSO
  8 | 0.9938922568658763 | GALAXY
  9 | 0.9938564131331261 | GALAXY
```

Inner data model

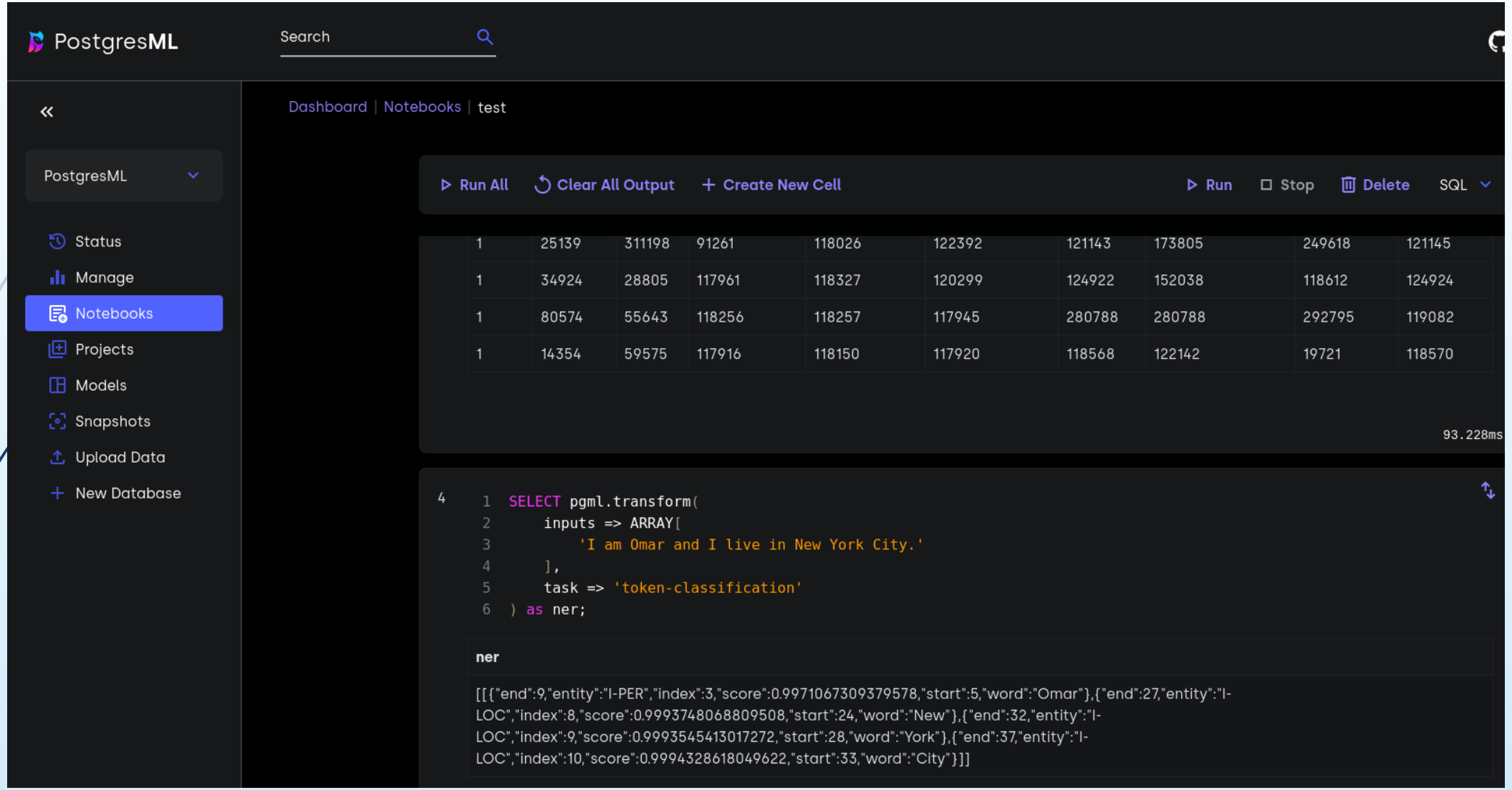
```
adult=#
adult=# select name, j #> '{data_processing_options,cla
  name   |            class             |  loss_func
---------+--------------------------------+--------------
 astra   | ["GALAXY", "QSO", "STAR"] | "MultiClass"
 titanic | [0, 1]                         | "Logloss"
 titanic | [0, 1]                         | "Logloss"
 boston  | []                             | "RMSE"
 adult   | ["<=50K", ">50K"]              | "Logloss"
(5 rows)
```

PostgeSQL vs ClickHouse

```
adult=# select * from ml_predict('amazon.cbm' , 'amazon','{
 RESOURCE,
 MGR_ID,
 ROLE_ROLLUP_1,
 ROLE_ROLLUP_2,
 ROLE_DEPTNAME,
 ROLE_TITLE,
 ROLE_FAMILY_DESC,
 ROLE_FAMILY,
 ROLE_CODE}' )
  LIMIT 10;

 index |       predict       | class
-------+---------------------+-------
 0     |   5.075591747501174 | 1
 1     |   4.677445251644691 | 1
 2     |  3.4881006705946156 | 1
 3     |   4.654735526605757 | 1
 4     |   4.546219076437382 | 1
 5     | -0.7881046669169504 | 0
 6     |   5.249330192285552 | 1
 7     |  4.5361327711227215 | 1
 8     |   4.542787758485275 | 1
 9     |  3.9540183530568065 | 1
(10 rows)

adult=#
```

```
    catboostEvaluate('/tmp/amazon.cbm',
                     RESOURCE,
                     MGR_ID,
                     ROLE_ROLLUP_1,
                     ROLE_ROLLUP_2,
                     ROLE_DEPTNAME,
                     ROLE_TITLE,
                     ROLE_FAMILY_DESC,
                     ROLE_FAMILY,
                     ROLE_CODE)  AS prediction,
^I    ACTION AS target
FROM amazon_train LIMIT 10;

SELECT
    catboostEvaluate('/tmp/amazon.cbm', RESOURCE, MGR
    ACTION AS target
FROM amazon_train
LIMIT 10

Query id: c4975c2f-9380-4619-8b07-2dc9e3886470

┌──────────prediction─┬─target─┐
│   5.075591747501174 │      1 │
│   4.677445251644691 │      1 │
│  3.4881006705946156 │      1 │
│   4.654735526605757 │      1 │
│   4.546219076437382 │      1 │
│ -0.7881046669169504 │      0 │
│   5.249330192285552 │      1 │
│  4.5361327711227215 │      1 │
│   4.542787758485275 │      1 │
│  3.9540183530568065 │      1 │
└─────────────────────┴────────┘

10 rows in set. Elapsed: 0.111 sec. Processed 8.19 th
```

PostgesML


PostgresML
Search
Dashboard | Notebooks | test
PostgresML
Status
Manage
Notebooks
Projects
Models
Snapshots
Upload Data
New Database
Run All
Clear All Output
Create New Cell
Run
Stop
Delete
SQL
1 25139 311198 91261 118026 122392 121143 173805 249618 121145
1 34924 28805 117961 118327 120299 124922 152038 118612 124924
1 80574 55643 118256 118257 117945 280788 280788 292795 119082
1 14354 59575 117916 118150 117920 118568 122142 19721 118570
93.228ms
4
SELECT pgml.transform(
inputs => ARRAY[
'I am Omar and I live in New York City.'
],
task => 'token-classification'
) as ner;
ner
[[{"end":9,"entity":"I-PER","index":3,"score":0.9971067309379578,"start":5,"word":"Omar"},{"end":27,"entity":"I-LOC","index":8,"score":0.9993748068809508,"start":24,"word":"New"},{"end":32,"entity":"I-LOC","index":9,"score":0.9993545413017272,"start":28,"word":"York"},{"end":37,"entity":"I-LOC","index":10,"score":0.9994328618049622,"start":33,"word":"City"}]]

pg_ml vs PostgesML

```
                    Table "public.titanic"
   Column    |       Type        | Collation |
-------------+-------------------+-----------+
id           | integer           |           |
passenger_id | integer           |           |
pclass       | integer           |           |
name         | text              |           |
sex          | text              |           |
age          | double precision  |           |
sibsp        | integer           |           |
parch        | integer           |           |
ticket       | text              |           |
fare         | double precision  |           |
cabin        | text              |           |
embarked     | character(1)      |           |
res          | boolean           |           |
```

convenient use of

categorical features

XGBoost

```
postgresml=# \d titanic
                    Table "public.titanic"
     Column     |       Type        | Collation
----------------+-------------------+----------
 index          | bigint            |
 unnamed:0      | bigint            |
 pclass         | bigint            |
 name           | text              |
 sib_sp         | bigint            |
 parch          | bigint            |
 ticket         | text              |
 fare           | double precision  |
 sex_male       | bigint            |
 nulls_1        | bigint            |
 nulls_2        | bigint            |
 cabin_mapped_1 | bigint            |
 cabin_mapped_2 | bigint            |
 cabin_mapped_3 | bigint            |
 cabin_mapped_4 | bigint            |
 cabin_mapped_5 | bigint            |
 cabin_mapped_6 | bigint            |
 cabin_mapped_7 | bigint            |
 cabin_mapped_8 | bigint            |
 embarked_q     | bigint            |
 embarked_s     | bigint            |
 survived       | bigint            |
Indexes:
    "ix_titanic_index" btree (index)
```