```
pip install fastai==0.7.0
```

```
pip install torchvision==0.1.9
```

```
pip install torch==0.4.1
```

```
%reload_ext autoreload
%autoreload 2
%matplotlib inline
```

```
from fastai.learner import *
```

```
from fastai.column_data import *
```

```
from google.colab import drive
drive.mount('/content/drive')
```

```
path_ratings='/content/drive/My Drive/ml-latest-small/ratings.csv'
```

```
ratings = pd.read_csv(path_ratings)
```

```
ratings.head()
```

	userId	movieId	rating	timestamp
0	1	1	4.0	964982703
1	1	3	4.0	964981247
2	1	6	4.0	964982224
3	1	47	5.0	964983815
4	1	50	5.0	964982931

```
g = ratings.groupby('userId')['rating'].count()
```

```
g
```

```
topUsers = g.sort_values(ascending=False)[:15]
```

```
topUsers
```

```
userId
414    2698
599    2478
474    2108
448    1864
274    1346
610    1302
68     1260
380    1218
606    1115
288    1055
249    1046
387    1027
182     977
307     975
603     943
Name: rating, dtype: int64
```

```
g = ratings.groupby('movieId')['rating'].count()
```

```
topMovies = g.sort_values(ascending=False)[:15]
```

```
topMovies
```

```
movieId
356     329
318     317
296     307
593     279
2571    278
260     251
480     238
110     237
589     224
527     220
2959    218
1       215
1196    211
50      204
2858    204
Name: rating, dtype: int64
```

```
top_r = ratings.join(topUsers, rsuffix='_r', how='inner', on='userId')
top_r = top_r.join(topMovies, rsuffix='_r', how='inner', on='movieId')

pd.crosstab(top_r.userId, top_r.movieId, top_r.rating, aggfunc=np.sum)
```

movieId	1	50	110	260	296	318	356	480	527	589	593	1196	2571	2858
userId														
68	2.5	3.0	2.5	5.0	2.0	3.0	3.5	3.5	4.0	3.5	3.5	5.0	4.5	5.0
182	4.0	4.5	3.5	3.5	5.0	4.5	5.0	3.5	4.0	2.0	4.5	3.0	5.0	5.0
249	4.0	4.0	5.0	5.0	4.0	4.5	4.5	4.0	4.5	4.0	4.0	5.0	5.0	4.5
274	4.0	4.0	4.5	3.0	5.0	4.5	4.5	3.5	4.0	4.5	4.0	4.5	4.0	5.0
288	4.5	NaN	5.0	5.0	5.0	5.0	5.0	2.0	5.0	4.0	5.0	4.5	3.0	NaN
307	4.0	4.5	3.5	3.5	4.5	4.5	4.0	3.5	4.5	2.5	4.5	3.0	3.5	4.0
380	5.0	4.0	4.0	5.0	5.0	3.0	5.0	5.0	NaN	5.0	5.0	5.0	4.5	NaN
387	NaN	4.5	3.5	4.5	5.0	3.5	4.0	3.0	NaN	3.5	4.0	4.5	4.0	4.5
414	4.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0	4.0	5.0	4.0	5.0	5.0	5.0
448	5.0	4.0	NaN	5.0	5.0	NaN	3.0	3.0	NaN	3.0	5.0	5.0	2.0	4.0
474	4.0	4.0	3.0	4.0	4.0	5.0	3.0	4.5	5.0	4.0	4.5	5.0	4.5	3.5
599	3.0	3.5	3.5	5.0	5.0	4.0	3.5	4.0	NaN	4.5	3.0	5.0	5.0	5.0
603	4.0	NaN	1.0	4.0	5.0	NaN	3.0	NaN	3.0	NaN	5.0	3.0	5.0	5.0
606	2.5	4.5	3.5	4.5	5.0	3.5	4.0	2.5	5.0	3.5	4.5	4.5	5.0	4.5
610	5.0	4.0	4.5	5.0	5.0	3.0	3.0	5.0	3.5	5.0	4.5	5.0	5.0	3.5

```
val_idxs = get_cv_idxs(len(ratings))
```

```
wd=2e-4
n_factors = 50
```

```
path ='/content/drive/My Drive/ml-latest-small'
```

```
cf = CollabFilterDataset.from_csv(path, 'ratings.csv', 'userId', 'movieId', 'rating')
```

```
learn = cf.get_learner(n_factors, val_idxs, 64, opt_fn=optim.Adam)
```

```
val_idxs
```

```
array([67037, 42175, 93850, ..., 67290, 33423, 98552])
```

```
learn.fit(1e-2, 2, wds=wd, cycle_len=1, cycle_mult=2)
```

```
Epoch                                                    100% 3/3 [00:19<00:00, 6.62s/it]
  3%|▌          | 36/1261 [00:00<00:06, 179.57it/s, loss=1.61]/usr/local/lib/python3.
  warnings.warn("nn.functional.sigmoid is deprecated. Use torch.sigmoid instead.")
epoch      trn_loss   val_loss
    0      0.743908   0.773024
    1      0.702123   0.751732
    2      0.599873   0.734226

[0.7342258466500664]
```

```
math.sqrt(0.735)
```

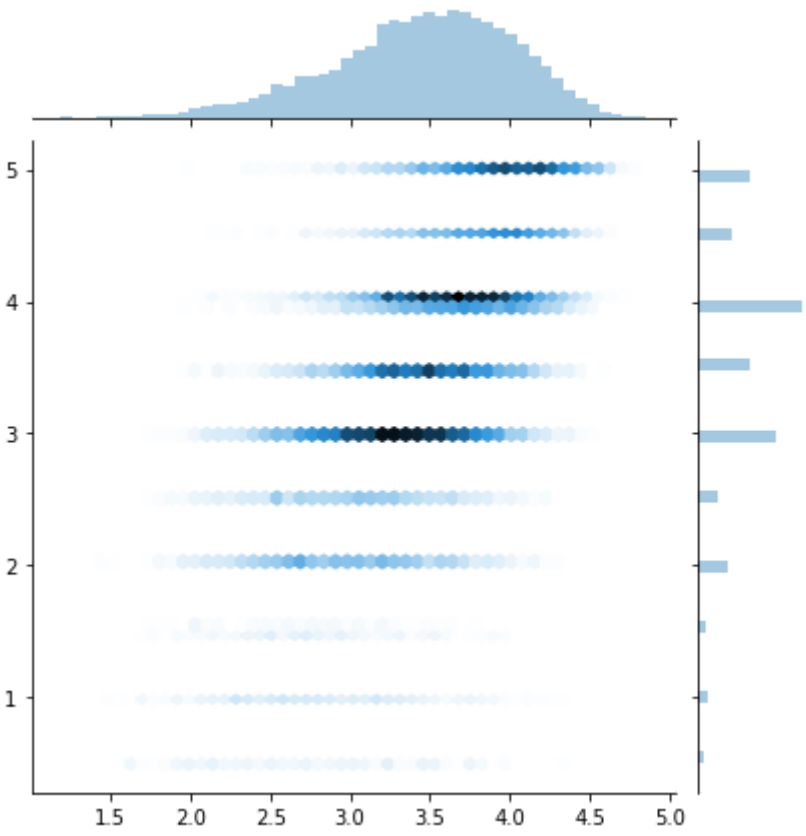
```
0.8573214099741123
```

RMSE = 0.857. Benchmark RMSE = 0.91

```
preds = learn.predict()
```

```
/usr/local/lib/python3.6/dist-packages/torch/nn/functional.py:1006: UserWarning: nn.f
  warnings.warn("nn.functional.sigmoid is deprecated. Use torch.sigmoid instead.")
```

```
y=learn.data.val_y
sns.jointplot(preds, y, kind='hex', stat_func=None);
```




```
m=learn.model; m.cuda()
```

```
EmbeddingDotBias(
  (u): Embedding(610, 50)
  (i): Embedding(9724, 50)
  (ub): Embedding(610, 1)
  (ib): Embedding(9724, 1)
)
```

Modelling from scratch

Dot product implementation

```
a = T([[1.,2],[3,4]])
b = T([[2.,2],[10,10]])
a,b
```

```
(tensor([[1., 2.],
         [3., 4.]], device='cuda:0'), tensor([[ 2.,  2.],
         [10., 10.]], device='cuda:0'))
```

```
a*b
```

```
tensor([[ 2.,  4.],
        [30., 40.]], device='cuda:0')
```

```
(a*b).sum(1)
```

```
tensor([ 6., 70.], device='cuda:0')
```

```
class DotProduct(nn.Module):
  def forward(self, u, m):
    return (u*m).sum(1)
```

```
myModel = DotProduct()
```

```
myModel.forward(a,b)
```

```
tensor([ 6., 70.], device='cuda:0')
```

Dot product model

```
u_uniq = ratings.userId.unique()
```

```
user2idx = {o:i for i,o in enumerate(u_uniq)}
```

```
ratings.userId = ratings.userId.apply(lambda x: user2idx[x])
```

```
ratings
```

	userId	movieId	rating	timestamp
0	0	1	4.0	964982703
1	0	3	4.0	964981247
2	0	6	4.0	964982224
3	0	47	5.0	964983815
4	0	50	5.0	964982931
...	...	...	...	...
100831	609	166534	4.0	1493848402
100832	609	168248	5.0	1493850091
100833	609	168250	5.0	1494273047
100834	609	168252	5.0	1493846352
100835	609	170875	3.0	1493846415

100836 rows × 4 columns

```
m_uniq = ratings.movieId.unique()
movie2idx = {o:i for i,o in enumerate(m_uniq)}
ratings.movieId = ratings.movieId.apply(lambda x: movie2idx[x])
```

```
ratings
```

	userId	movieId	rating	timestamp
0	0	0	4.0	964982703
1	0	1	4.0	964981247
2	0	2	4.0	964982224
3	0	3	5.0	964983815
4	0	4	5.0	964982931
...	...	...	...	...
100831	609	3120	4.0	1493848402
100832	609	2035	5.0	1493850091
100833	609	3121	5.0	1494273047
100834	609	1392	5.0	1493846352
100835	609	2873	3.0	1493846415

100836 rows × 4 columns

```
n_users=int(ratings.userId.nunique())
n_movies=int(ratings.movieId.nunique())
```

```
n_users,n_movies
```

```
n_users,n_movies
```

```
(610, 9724)
```

```
cf.n_users
```

```
610
```

```
cf.n_items
```

```
9724
```

```
class EmbeddingDot(nn.Module):
    def __init__(self, n_users, n_movies):
        super().__init__()
        self.u = nn.Embedding(n_users, n_factors)
        self.m = nn.Embedding(n_movies, n_factors)
        self.u.weight.data.uniform_(0,0.05)
        self.m.weight.data.uniform_(0,0.05)

    def forward(self, cats, conts):
        users,movies = cats[:,0],cats[:,1]
        u,m = self.u(users),self.m(movies)
        return (u*m).sum(1).view(-1, 1)

x = ratings.drop(['rating', 'timestamp'],axis=1)
y = ratings['rating'].astype(np.float32)
```

```
x
```

	userId	movieId
0	0	0
1	0	1
2	0	2
3	0	3
4	0	4
...	...	...
100831	609	3120
100832	609	2035
100833	609	3121
100834	609	1392
100835	609	2873

100836 rows × 2 columns

```
y
```

```
0         4.0
1         4.0
2         4.0
3         5.0
4         5.0
          ...
100831    4.0
100832    5.0
100833    5.0
100834    5.0
100835    3.0
Name: rating, Length: 100836, dtype: float32
```

```
data = ColumnarModelData.from_data_frame(path, val_idxs, x, y, ['userId', 'movieId'], 64)
```

```
wd=1e-5
model = EmbeddingDot(n_users, n_movies).cuda()
opt = optim.SGD(model.parameters(), 1e-1, weight_decay=wd, momentum=0.9)
```

```
fit(model, data, 3, opt, F.mse_loss)
```

```
Epoch                                                100% 3/3 [00:15<00:00, 5.22s/it]
epoch      trn_loss   val_loss
    0      1.613996   1.598949
    1      1.069858   1.293917
    2      0.860241   1.228701

[1.2287012057092292]
```

```
set_lrs(opt, 0.01)
```

```
fit(model, data, 3, opt, F.mse_loss)
```

```
Epoch                                                100% 3/3 [00:15<00:00, 5.03s/it]
epoch      trn_loss   val_loss
    0      0.687554   1.151557
    1      0.682628   1.139595
    2      0.646362   1.134128

[1.134128233197957]
```

Add Bias to the model

```
min_rating,max_rating = ratings.rating.min(),ratings.rating.max()
min_rating,max_rating
```

```
(0.5, 5.0)
```

```
def get_emb(ni,nf):
    e = nn.Embedding(ni, nf)
    e.weight.data.uniform_(-0.01,0.01)
    return e
```

```
    return e

class EmbeddingDotBias(nn.Module):
    def __init__(self, n_users, n_movies):
        super().__init__()
        (self.u, self.m, self.ub, self.mb) = [get_emb(*o) for o in [
            (n_users, n_factors), (n_movies, n_factors), (n_users,1), (n_movies,1)
        ]]

    def forward(self, cats, conts):
        users,movies = cats[:,0],cats[:,1]
        um = (self.u(users)* self.m(movies)).sum(1)
        res = um + self.ub(users).squeeze() + self.mb(movies).squeeze()
        res = F.sigmoid(res) * (max_rating-min_rating) + min_rating
        return res.view(-1, 1)


wd=2e-4
model = EmbeddingDotBias(cf.n_users, cf.n_items).cuda()
opt = optim.SGD(model.parameters(), 1e-1, weight_decay=wd, momentum=0.9)


fit(model, data, 3, opt, F.mse_loss)
```

```
Epoch                                                 100% 3/3 [00:17<00:00, 5.73s/it]
  4%|▌          | 50/1261 [00:00<00:04, 244.05it/s, loss=1.42]/usr/local/lib/python3.
  warnings.warn("nn.functional.sigmoid is deprecated. Use torch.sigmoid instead.")
 epoch      trn_loss   val_loss
     0      0.800973   0.818024
     1      0.753902   0.7943
     2      0.755668   0.787904

 [0.7879037667338693]
```

```
set_lrs(opt, 1e-2)


fit(model, data, 3, opt, F.mse_loss)
```

```
Epoch                                                 100% 3/3 [00:16<00:00, 5.64s/it]
  3%|▍          | 44/1261 [00:00<00:05, 213.77it/s, loss=0.673]/usr/local/lib/python3
  warnings.warn("nn.functional.sigmoid is deprecated. Use torch.sigmoid instead.")
 epoch      trn_loss   val_loss
     0      0.708329   0.781361
     1      0.707217   0.77984
     2      0.706677   0.7794

 [0.7793996662940351]
```

Creating a neural net

```
class EmbeddingNet(nn.Module):
    def __init__(self, n_users, n_movies, nh=10, p1=0.05, p2=0.5):
        super().__init__()
```

```
        (self.u, self.m) = [get_emb(*o) for o in [
            (n_users, n_factors), (n_movies, n_factors)]]
        self.lin1 = nn.Linear(n_factors*2, nh)
        self.lin2 = nn.Linear(nh, 1)
        self.drop1 = nn.Dropout(p1)
        self.drop2 = nn.Dropout(p2)

    def forward(self, cats, conts):
        users,movies = cats[:,0],cats[:,1]
        x = self.drop1(torch.cat([self.u(users),self.m(movies)], dim=1))
        x = self.drop2(F.relu(self.lin1(x)))
        return F.sigmoid(self.lin2(x)) * (max_rating-min_rating+1) + min_rating-0.5


wd=1e-5
model = EmbeddingNet(n_users, n_movies).cuda()
opt = optim.Adam(model.parameters(), 1e-3, weight_decay=wd)


fit(model, data, 3, opt, F.mse_loss)
```

```
Epoch                                                 100% 3/3 [00:20<00:00, 6.84s/it]
  3%|▌          | 40/1261 [00:00<00:06, 190.07it/s, loss=2.34]/usr/local/lib/python3.
  warnings.warn("nn.functional.sigmoid is deprecated. Use torch.sigmoid instead.")
 epoch      trn_loss   val_loss
     0      0.871311   0.79227
     1      0.790699   0.774544
     2      0.780993   0.7681

 [0.7681002917225658]
```

```
set_lrs(opt, 1e-3)


fit(model, data, 3, opt, F.mse_loss)
```

```
Epoch                                                 100% 3/3 [00:20<00:00, 6.84s/it]
  3%|▌          | 37/1261 [00:00<00:07, 170.42it/s, loss=0.698]/usr/local/lib/python3
  warnings.warn("nn.functional.sigmoid is deprecated. Use torch.sigmoid instead.")
 epoch      trn_loss   val_loss
     0      0.751868   0.770992
     1      0.738822   0.773406
     2      0.753004   0.772758

 [0.7727579698184548]
```