Neural BLACKLIST

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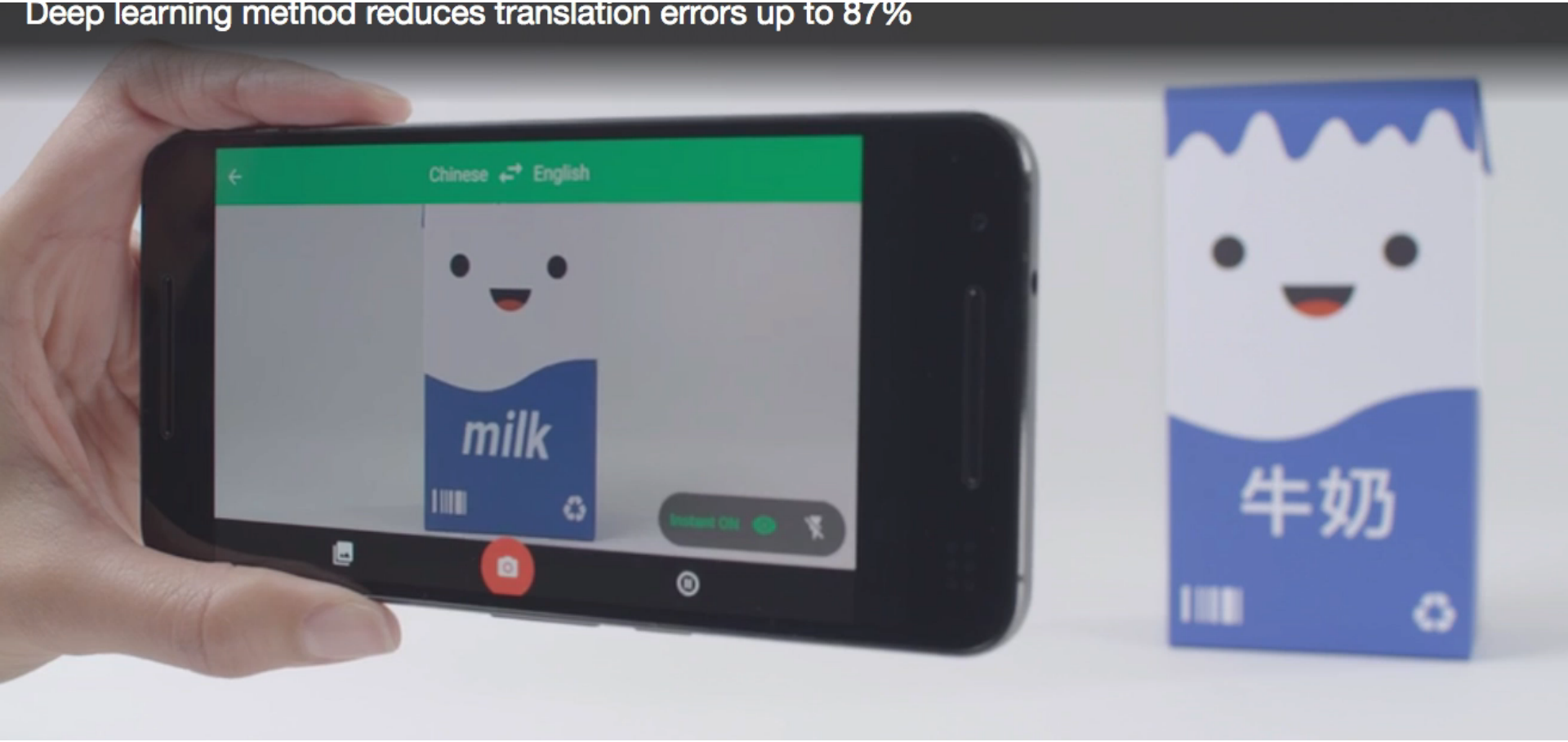
Ruxcon

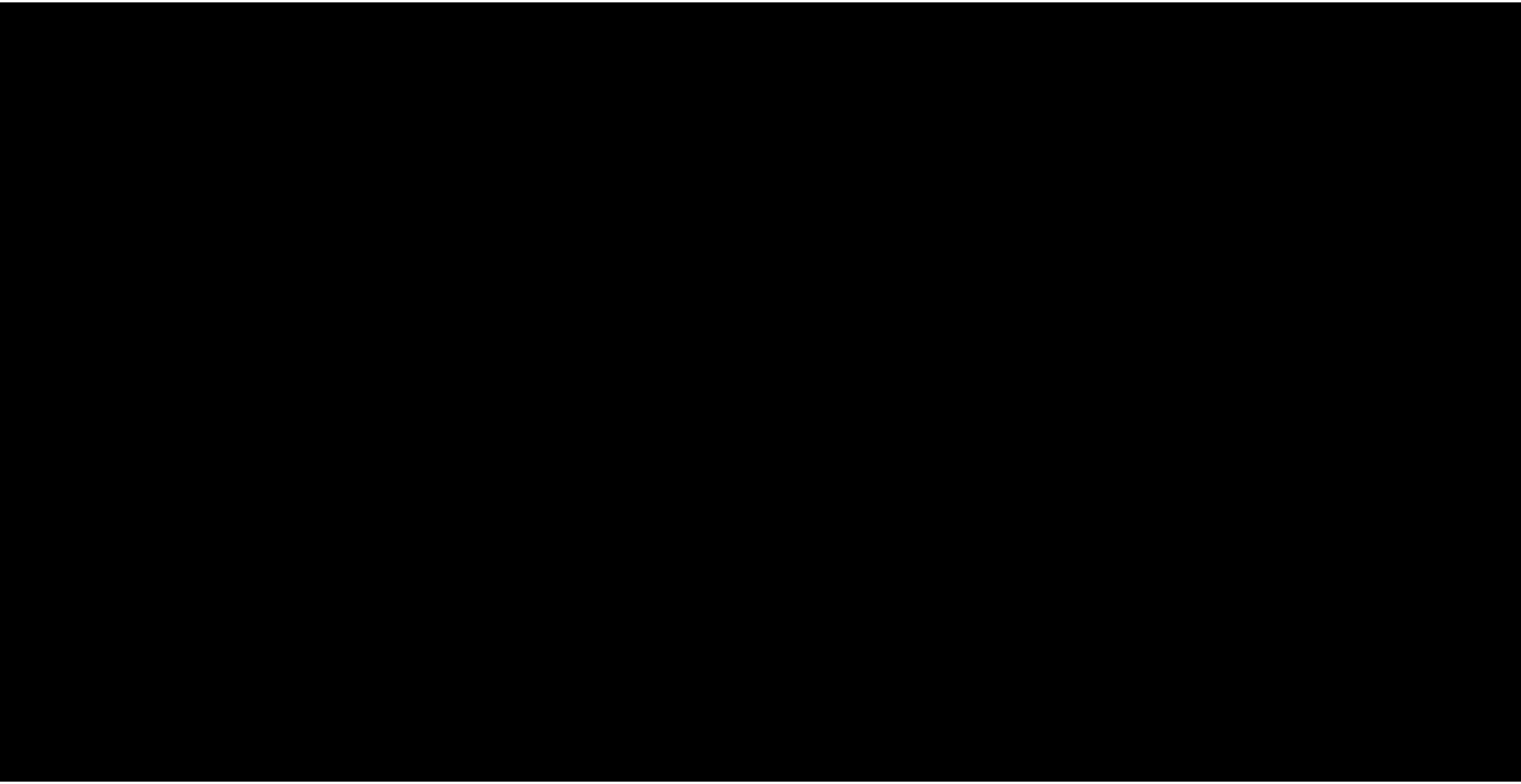
Deep Learning



Deep Learning

Deep Learning

Deep Learning



In The Old Days

Today

Filter by threat: Botnet C&Cs | Payment Sites | Distribution Sites

Filter by malware: TeslaCrypt | CryptoWall | TorrentLocker | PadCrypt | Locky | CTB-Locker | FAKBEN | PayCrypt | DMALocker | Cerber | Sage

Dateadded (UTC)	Threat	Malware	Host (?)	Domain Registrar (?)	IP address (ASN, Cou
2017-08-20 06:45	Payment Site	Cerber	qfjhpgbefuhenjp7.1e1jbc.top	Eranet International Limited	92.63.91.45 (Latvia)
2017-08-14 16:17	Payment Site	Cerber	oqwygprskqv65j72.1fs9pz.top	Eranet International Limited	104.244.156.10 (Un
2017-08-12 15:43	Payment Site	Cerber	oqwygprskqv65j72.14jqyo.top	Eranet International Limited	103.11.65.175 (Unit
2017-08-08 14:01	Payment Site	Cerber	oqwygprskqv65j72.1kh9ct.top	Eranet International Limited	103.11.65.175 (Unit
2017-08-04 10:52	Payment Site	Cerber	oqwygprskqv65j72.13rdvu.top	Eranet International Limited	103.11.65.165 (Unit
2017-07-31 18:19	Payment Site	Cerber	oqwygprskqv65j72.1hbdbx.top	Eranet International Limited	103.11.65.165 (Unit
2017-07-30 22:35	Payment Site	Cerber	oqwygprskqv65j72.13gpqd.top	Eranet International Limited	103.11.65.165 (Unit
2017-07-27 18:46	Payment Site	Cerber	qfjhpgbefuhenjp7.16g9ub.top	Eranet International Limited	107.181.161.207 (U
2017-07-25 14:58	Payment Site	Cerber	hjhqmbxyinislkkt.1jmip6.top	Eranet International Limited	155.94.213.132 (Un
2017-07-23 13:11	Payment Site	Cerber	qfjhpgbefuhenjp7.13iuvw.top	Eranet International Limited	107.181.161.207 (U
2017-07-21 01:20	Payment Site	Cerber	xpcx6erilkjced3j.1n5mod.top	Eranet International Limited	185.101.218.131 (U
2017-07-21 00:57	Payment Site	Cerber	qfjhpgbefuhenjp7.158ugp.top	Eranet International Limited	107.181.161.207 (U
2017-07-18 17:24	Payment Site	Cerber	hjhqmbxyinislkkt.1bcnad.top	Eranet International Limited	104.200.67.22 (Unit
2017-07-18 11:29	Payment Site	Cerber	qfjhpgbefuhenjp7.1fcfjn.top	Eranet International Limited	107.181.161.207 (U
2017-07-18 10:37	Payment Site	Cerber	xpcx6erilkjced3j.19kdeh.top	Eranet International Limited	107.150.18.186 (Un
2017-07-17 00:29	Payment Site	Cerber	hjhqmbxyinislkkt.18zrup.top	Eranet International Limited	104.200.67.22 (Unit
2017-07-14 22:00	Payment Site	Cerber	qfjhpgbefuhenjp7.1225wj.top	Eranet International Limited	107.181.161.207 (U

Source: https://ransomwaretracker.abuse.ch/tracker/cerber/

CryptoLocker

Locky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RIGEK-Cerber

Problems


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Machine Learning

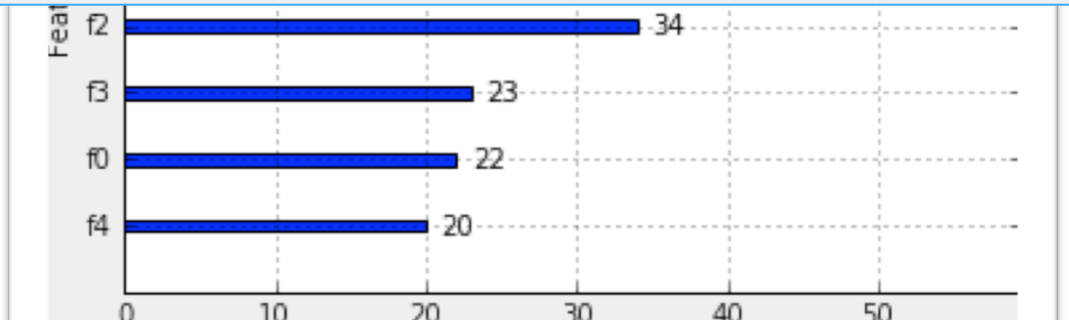
XGBoost, SVM, Random Forest, ...

```
trainx, testx, trainy, testy = train_test_split(X, Y, test_size=0.3, random_state=7)
trainset, testset = xgb.DMatrix(trainx, trainy), xgb.DMatrix(testx)

params = {'max_depth':10, 'eta':1, 'silent':1, 'objective':'binary:logistic' }
model = xgb.train(params, trainset, num_boost_round=10)

predictions = model.predict(testset)
```

```
booster[0]:
0:[f1<127.5] yes=1,no=2,missing=1
        1:[f7<28.5] yes=3,no=4,missing=3
        3:[f5<30.95] yes=7,no=8,missing=7
                7:[f0<5.5] yes=15,no=16,missing=15
                15:leaf=-1.89091
                16:leaf=-0.5
                8:[f6<0.9045] yes=17,no=18,missing=17
```

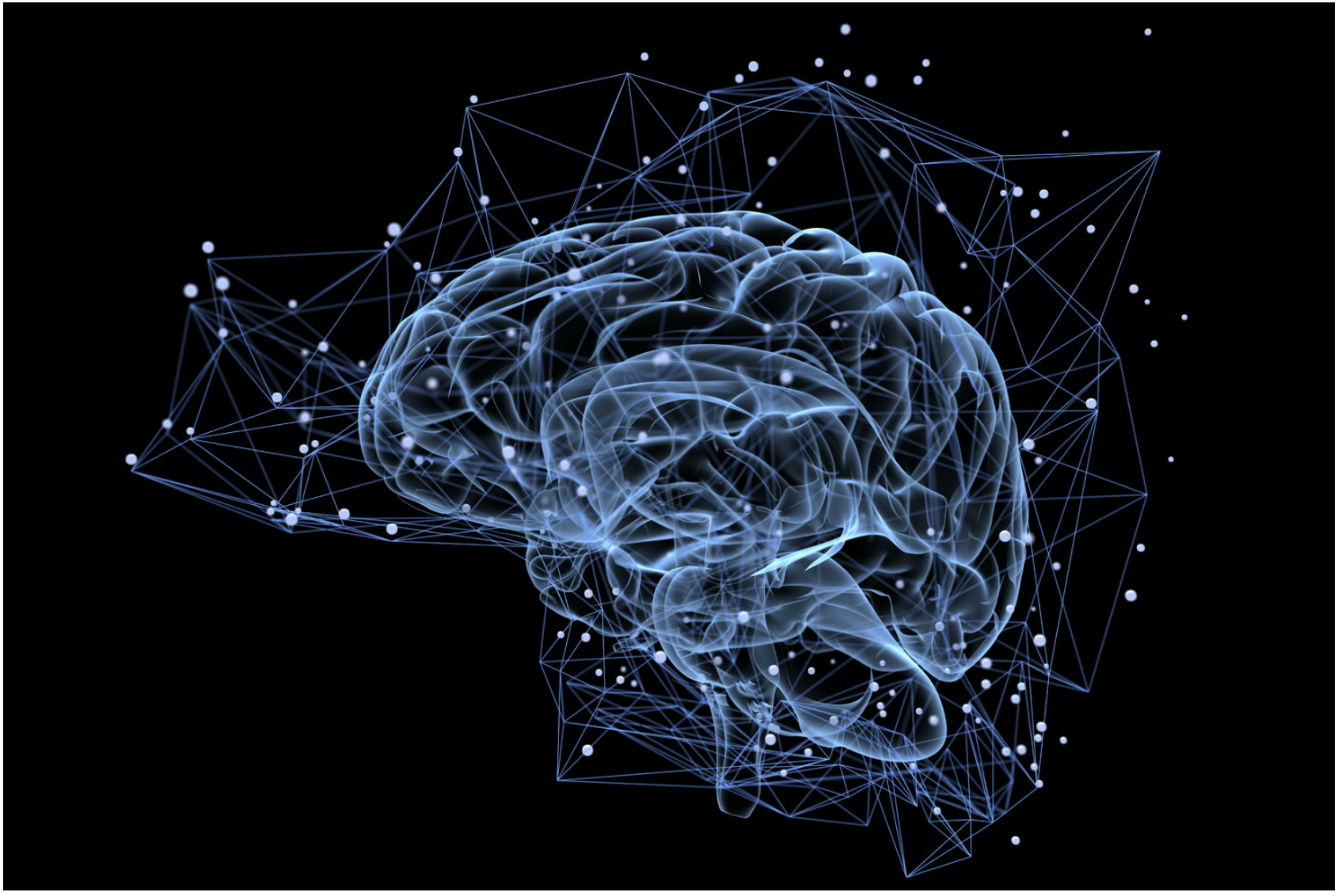


Would Traditional ML Work?
XGBoost/SVM/RandomForest

- Pros
  - Easy to program
  - Very fast training
  - Perform well against tabular input data
  - Use human intelligence and heuristics
- Cons
  - Hard to debug when it mis-predicts
  - Development cost is high
  - Feature engineering is required

Deep Learning

Neural Network



Malicious URL Detection

```
Tensorboard logs dir for this run is model/checkpoint/run1
Model loaded in 2.6 sec
Classification finished in 5.2 sec
Result saved in 0.0 sec
mail.loft.com/a/tBYhQ9GBgYd1XB9XjnHNuJ8T0ct/freeship?EMAIL_HASH=c0f53badcf51dd5ae65050f2d95b6f1c&email=sudheer.kumar@infogain.com legitimate
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1onabcf.ru:80/yPY2iIcC/3oVS15.php?id=peter.jackson@pfipaer.com cryptolocker
rlqjhwmu.com locky
icjwdktucoaio.com locky
click.email.vegas.com/?qs=16bc3fc881c351af16ea2d946[illegible]6802ff4b1c72 legitimate
www.facebook.com/ legitimate
p27dokhpz2n7nvgr.1cglxz.top cerber-rigek
p27dokhpz2n7nvgr.12smak.top cerber-rigek
w3.org/TR/html4/loose.dtd legitimate
www.tahitinuitravel.biz/ legitimate
www.rivieraholidays.in/ legitimate
www.tahiti-infos.com/Intemperies-a-Tahiti-la-piste-aeroportuaire-est-fermee-jusqu-a-nouvel-ordre_a157036.html legitimate
www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd legitimate
www.spiceworks.com/ legitimate
www.facebook.com/n/?kjohannesdottir1%2Fposts%2F10211634755642816&comment_id=10211635744347533&aref=1485111640385846&medium=email&mid=546b3b4
7&bcode=1.1485117353.AbnjnjRtQytXnFOy&n_m=margret%40valitor.is&lloc=1st_cta legitimate
www.vinnumalastofnun.is/ legitimate
4kqd3hmqgptupi3p.wz139z.top cerber-rigek
27lelchgcvs2wpm7.b7mciu.top cerber-rigek
ffoqr3ug7m726zou.do9wwg.top cerber-rigek
www.husbot.is/ legitimate
www.boksala.is/valitorpaymentgateway/payment/response/?Kortategund=VISA&KortnumerSidustu=7172&KortnumerStjarnad=415552******7172&Dagsetning=
9&Faerslunumer=0384273&VefverslunSalaID=c3a61021-9998-4e06-bc91-d52b74c87cb2&Tilvisunarnumer=200004785&RafraenUndirskriftSvar=0aa4a3e88b3517
```
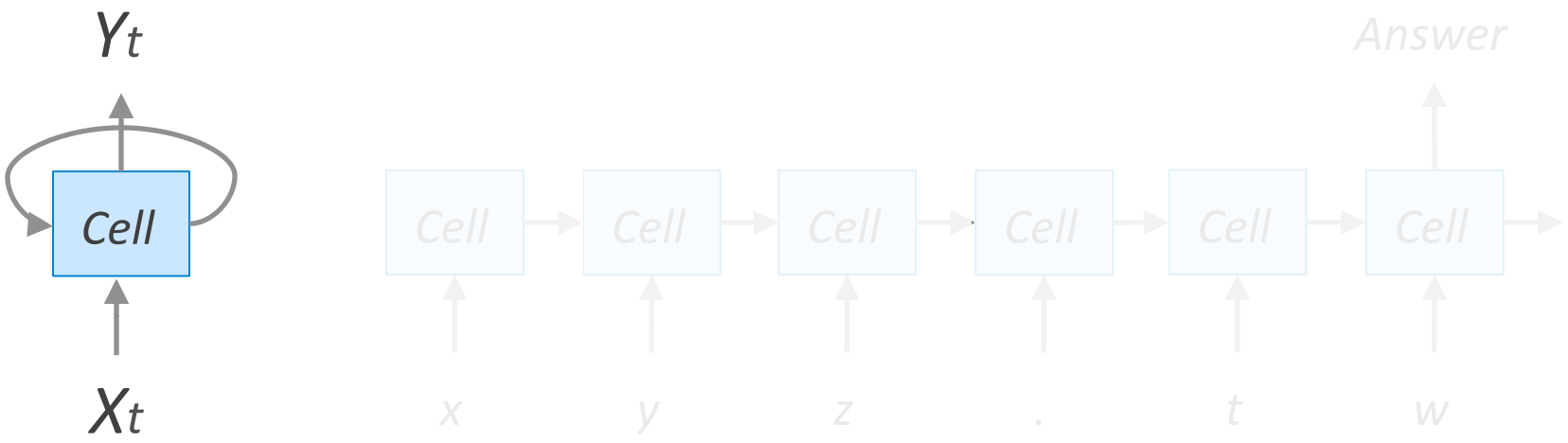
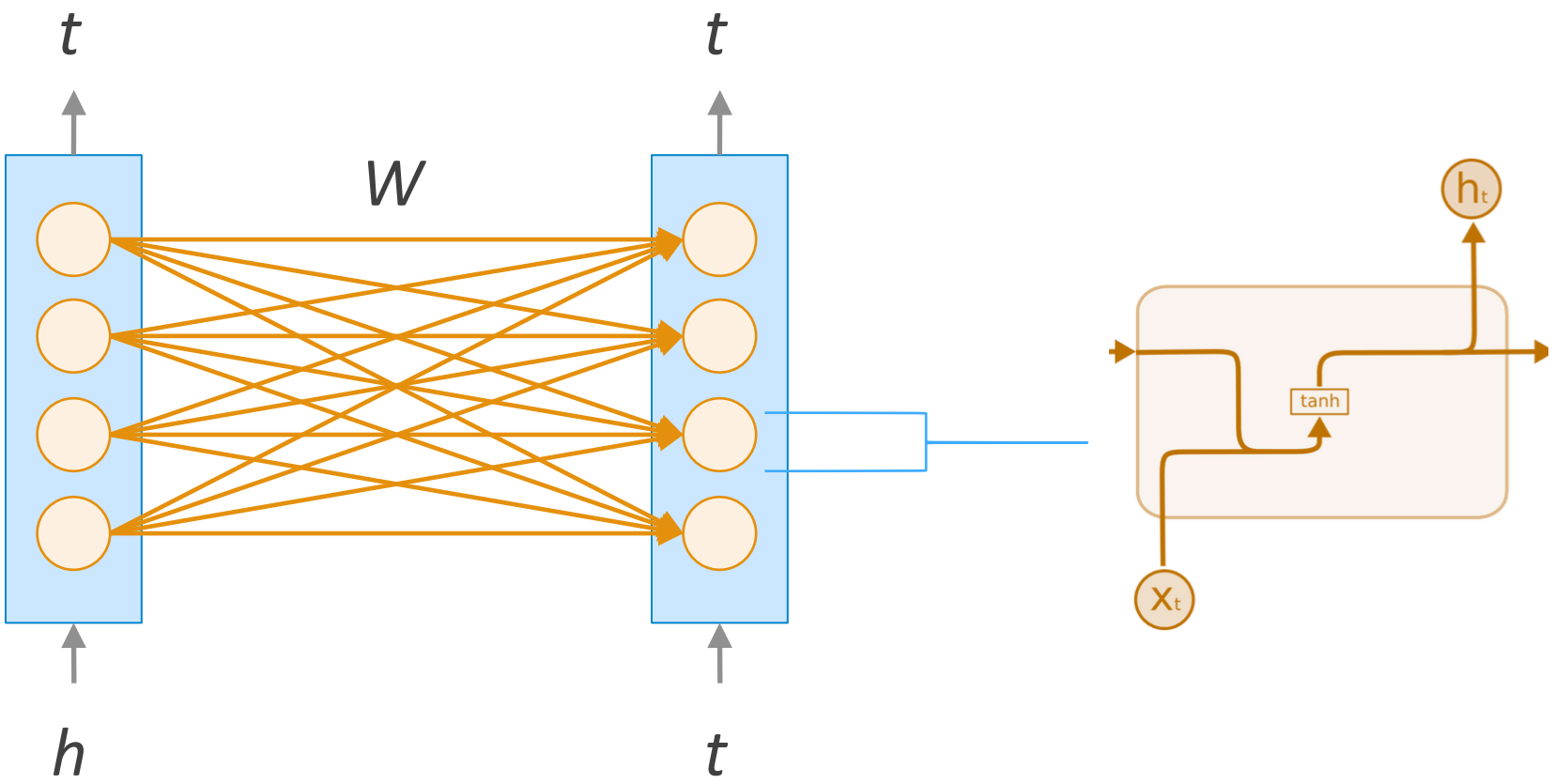

DEMO

Deep Learning

Recurrent neural network (RNN)

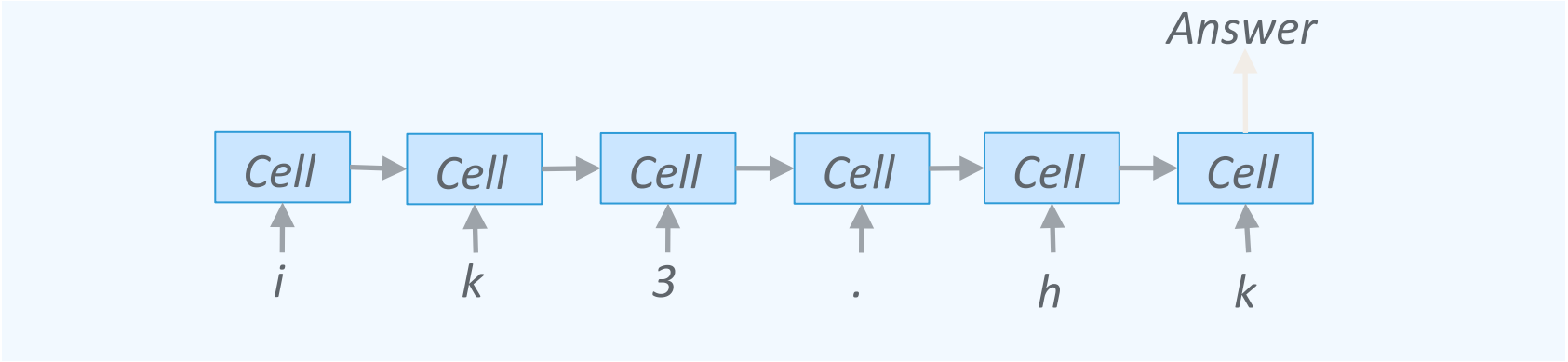


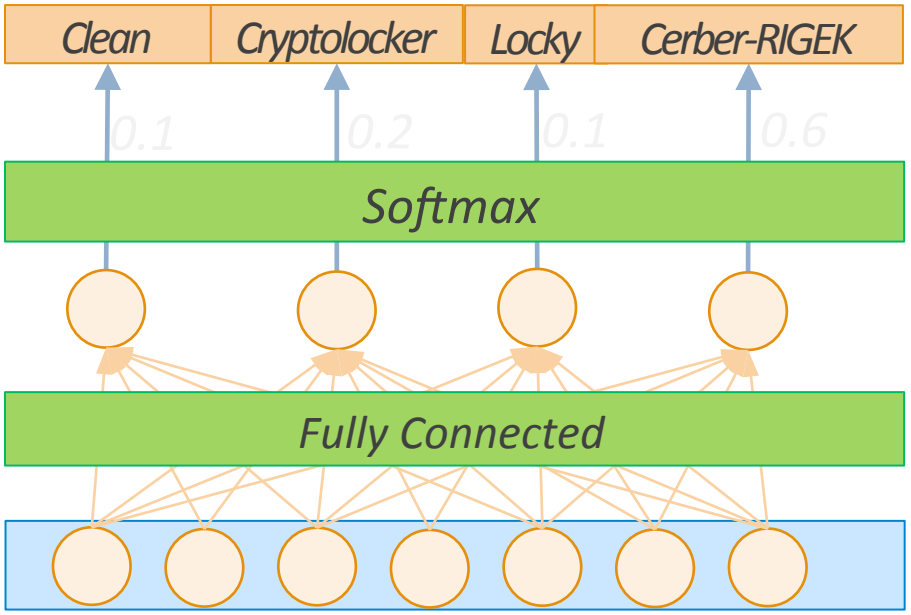
RNN Cell and Connections



Classification Using RNN Cell

Cost: softmax cross entropy

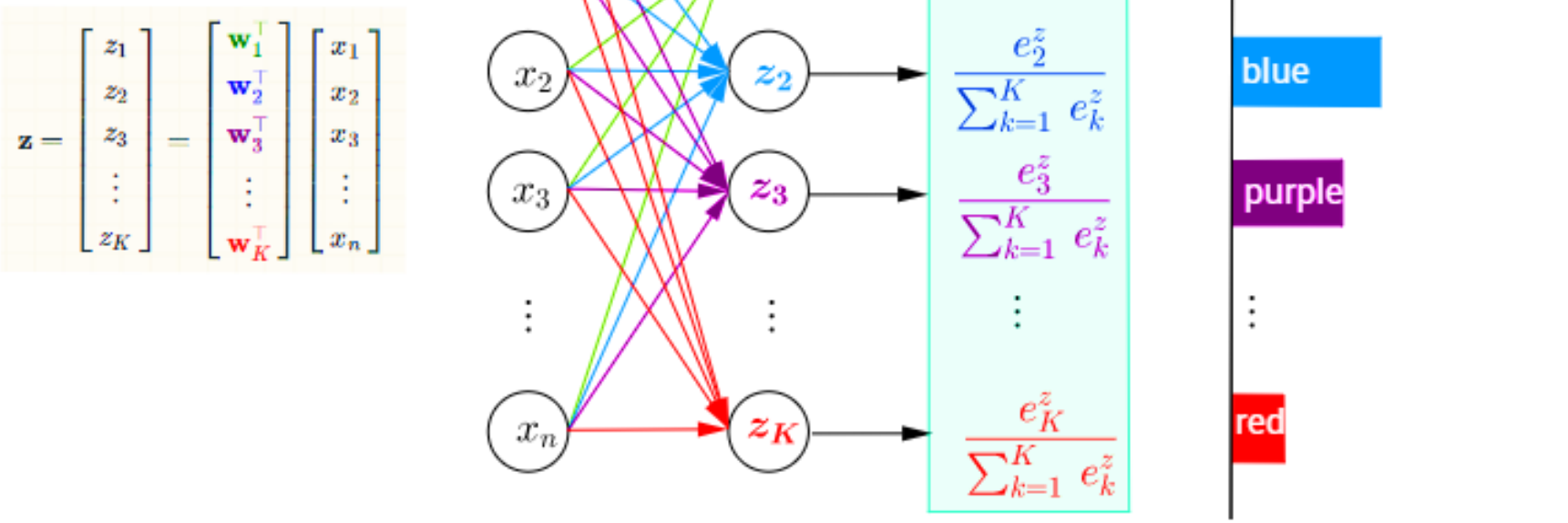




Classification Using RNN Cell

Training: Back Propagation Through Time

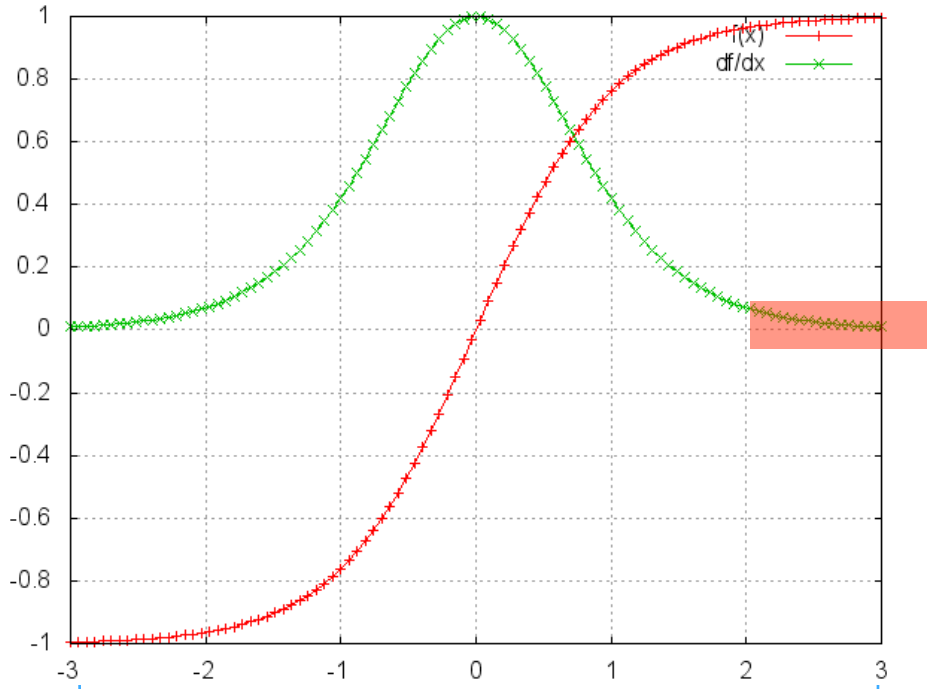
Multi-Class Classification with NN and SoftMax Function



Source: https://stats.stackexchange.com/questions/273465/neural-network-softmax-activation

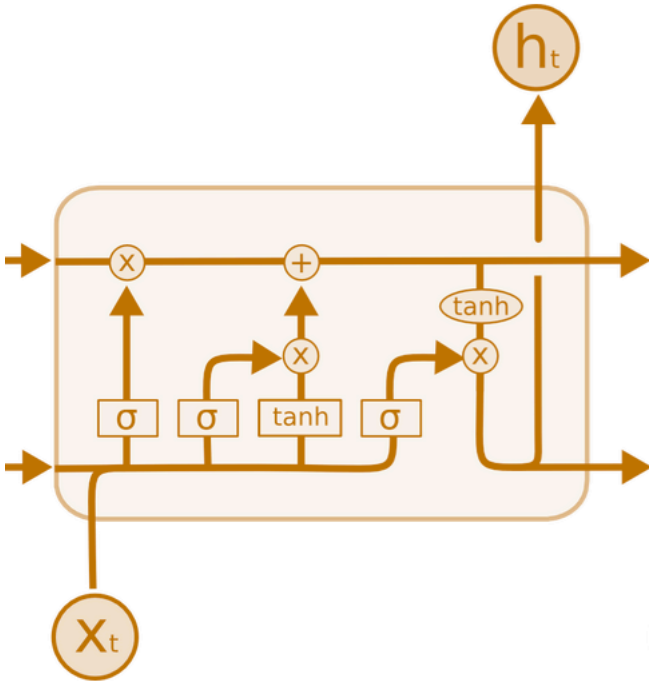
RNN Cell

Vanishing Gradient Problem



LSTM Cell

Long Short Term Memory



$$X = X_t \mid H_{t-1}$$

$$f = \sigma(X.W_f + b_f)$$

$$u = \sigma(X.W_u + b_u)$$

$$r = \sigma(X.W_r + b_r)$$

$$X' = \tanh(X.W_c + b_c)$$

$$C_t = f * C_{t-1} + u * X'$$

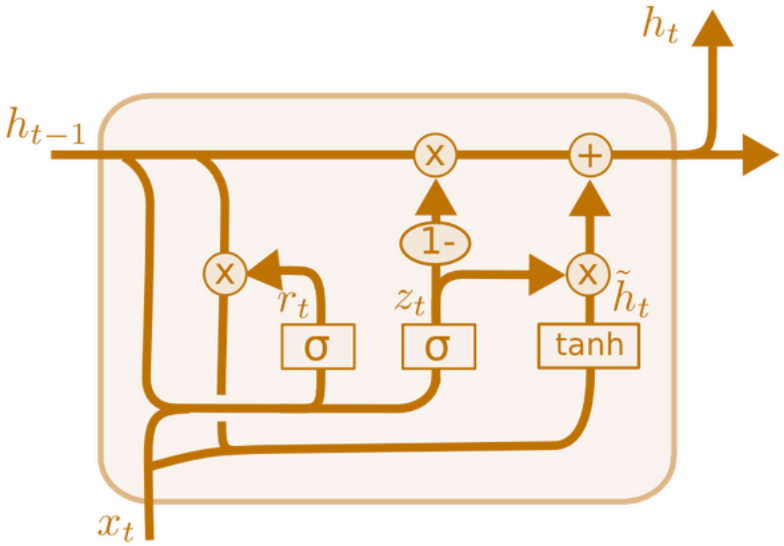
$$H_t = r * \tanh(C_t)$$

$$Y_t = \text{softmax}(H_t.W + b)$$

Source: http://colah.github.io/posts/2015-08-Understanding-LSTMs/

GRU Cell

Gated Recurrent Unit



$$z_t = \sigma\left(W_z \cdot [h_{t-1}, x_t]\right)$$

$$r_t = \sigma\left(W_r \cdot [h_{t-1}, x_t]\right)$$

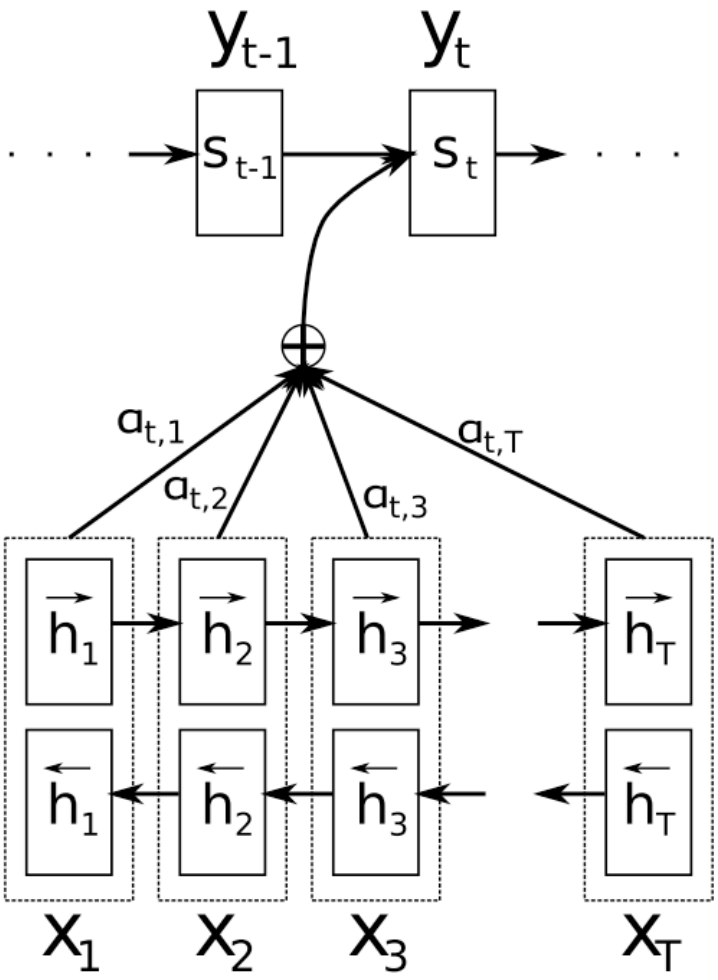
$$\tilde{h}_t = \tanh\left(W \cdot [r_t * h_{t-1}, x_t]\right)$$

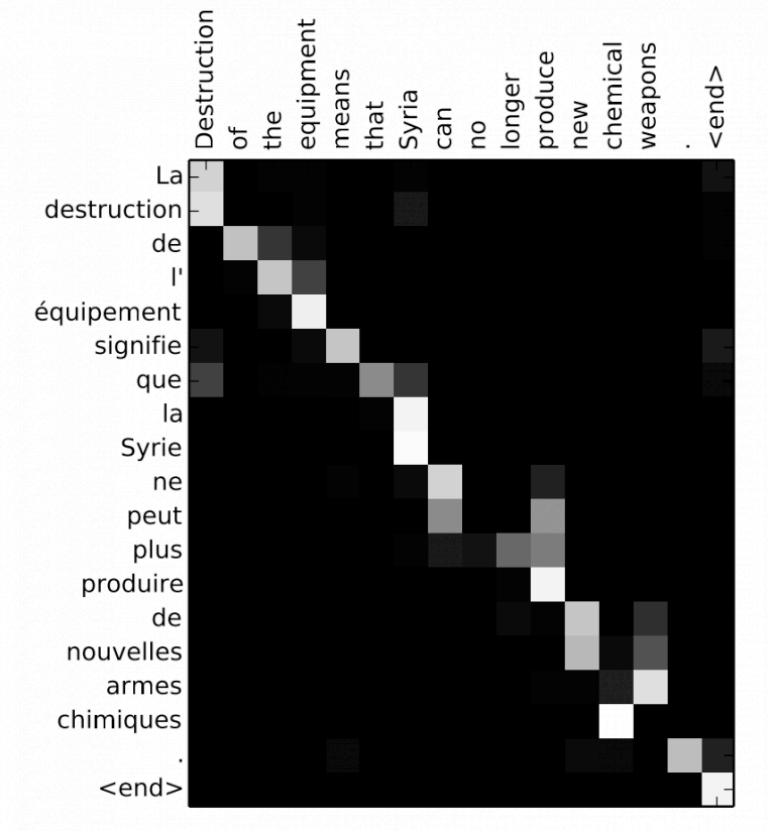
$$h_t = (1 - z_t) * h_{t-1} + z_t * \tilde{h}_t$$

Source: http://colah.github.io/posts/2015-08-Understanding-LSTMs/

RNN with Attention

Example: Neural Machine Translation (NMT)





Source: https://arxiv.org/pdf/1409.0473.pdf

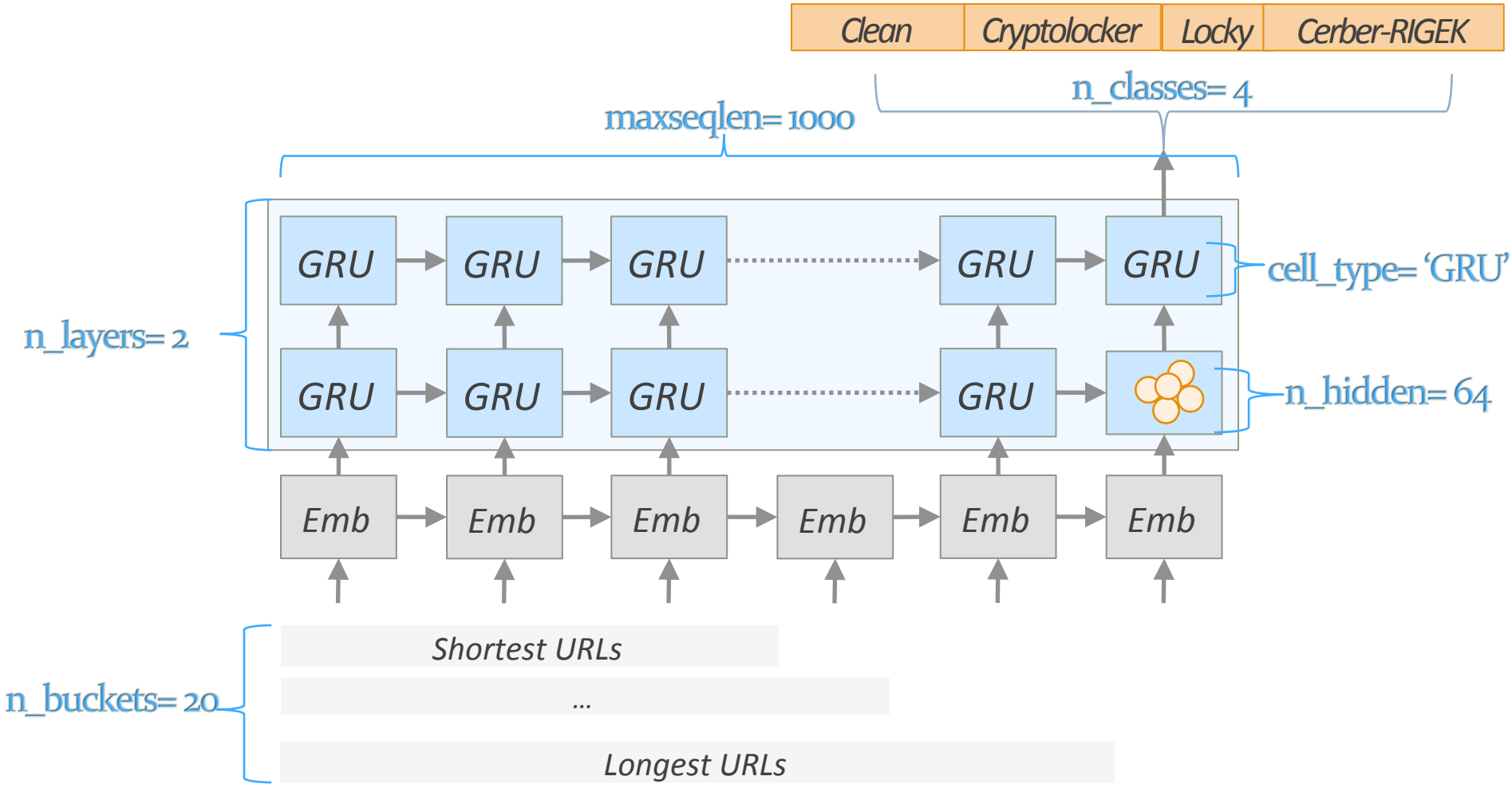
Embedding

- Symbols do not carry their natural semantics within them whereas continuous signals such as audios and videos do.

www.facebook.com/n/?kjoha

Neural Blacklist Network

Architecture & Hyper parameters



Feature & Dataset

- Feature

```
>> batch_x[2]
array([101,  46, 119, 101, 116, 115, 101,  97, 108, 110, 101, 119, 115,
       108, 101, 116, 116, 101, 114,  46,  99, 111, 109,  47, 113,  47,
        74,  83,  56, 104,  87,  74, 108,  69, 111, 107, 119, 100,  69,
        73, 106, 115,  99,  81, 109,  88, 116, 102,  95, 115,  66,  48,
       122,  69,  72,  83, 119,  99, 110,  52,  55, 104, 105,  86,  97,
        55,  87,  74,  45,  76,  49,  74,  56,  81, 113, 112, 122, 118,
       105, 117, 106,  69,  86,   0,   0,   0,   0,   0,   0,   0,   0], dtype=int32)
>> tochar(batch_x[2])
'e.wetsealnewsletter.com/q/JS8hWJlEokwdEIjscQmXtf_sB0zEHSwcn47hiVa7WJ-L1J8QqpzviujEV\x00\
```

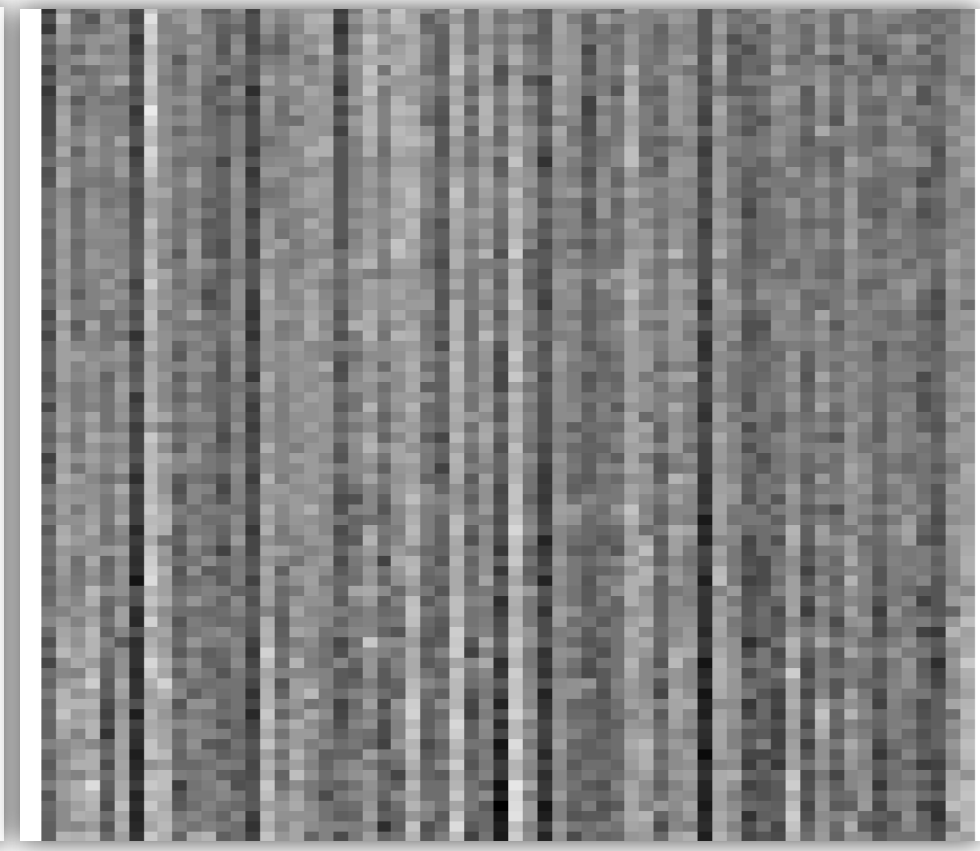
- Dataset
  - Sourcing
    - Legitimate URLs: Akamai log
    - Cryptolocker: Malware operations team
    - Locky v2/ Cerber-RIGEK : Ransomware tracker
  - Splits
    - train : validation : test = 0.1 : 0.1 : 0.8

RNN Model Space Analysis

Tensorboard
Network States

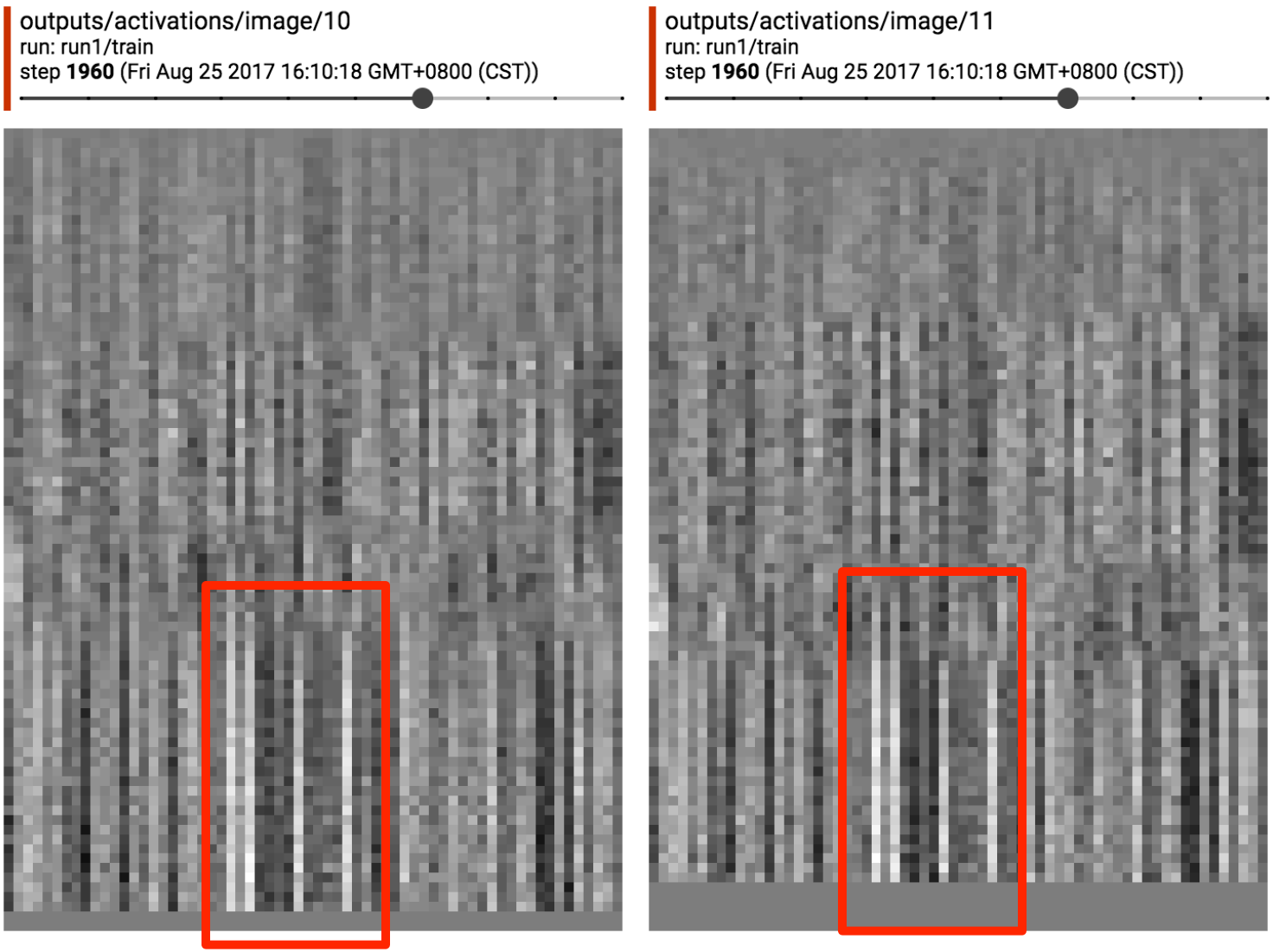
Before Training

After Training



Tensorboard

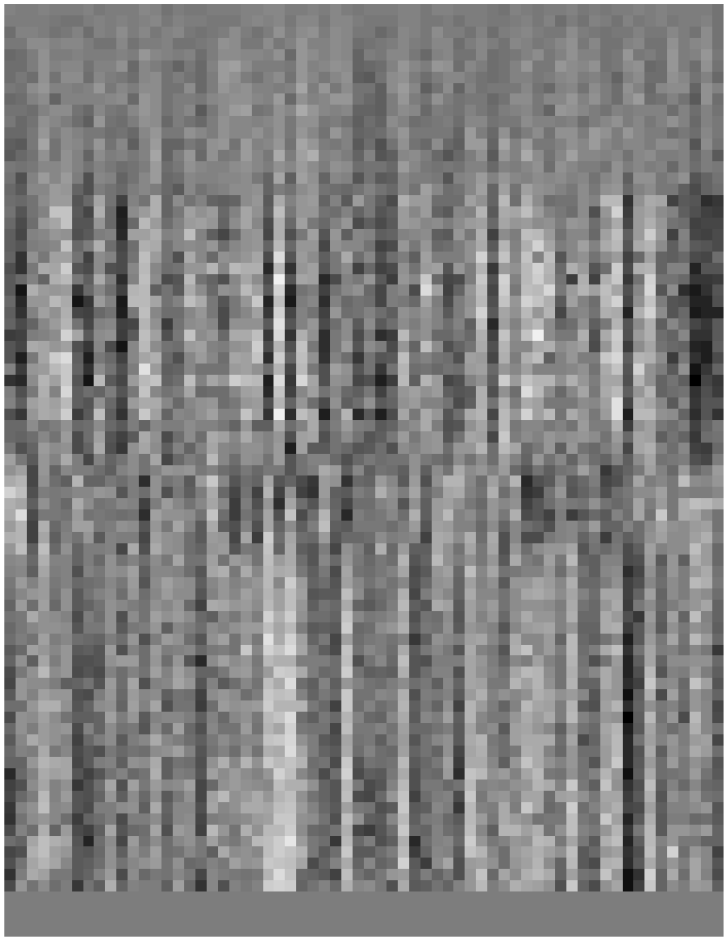
Activations – class A



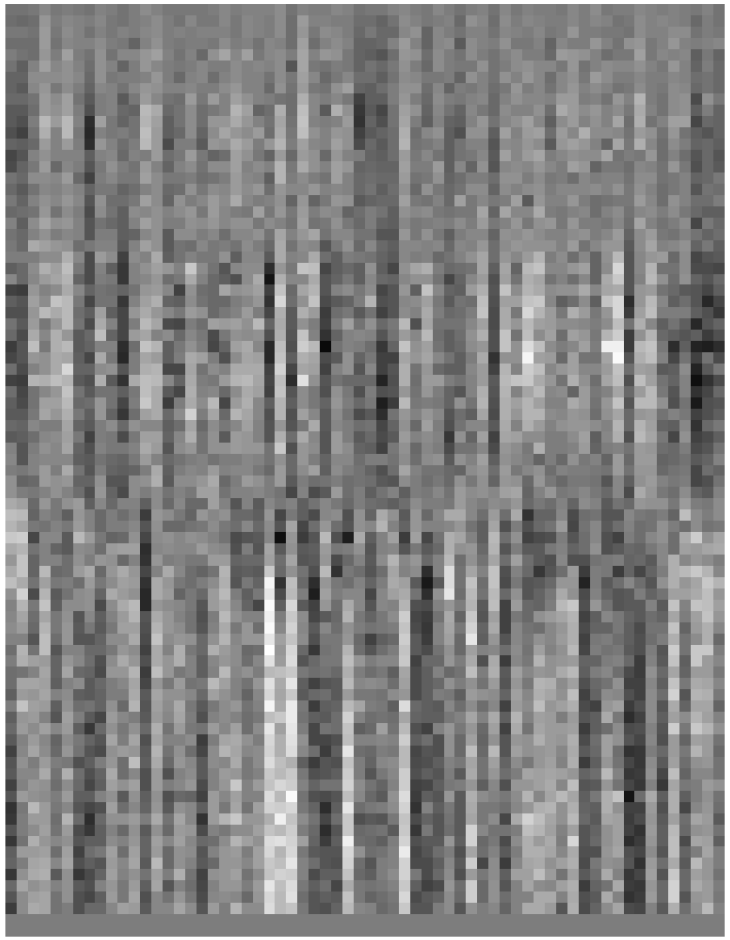
Tensorboard

Activations – class B

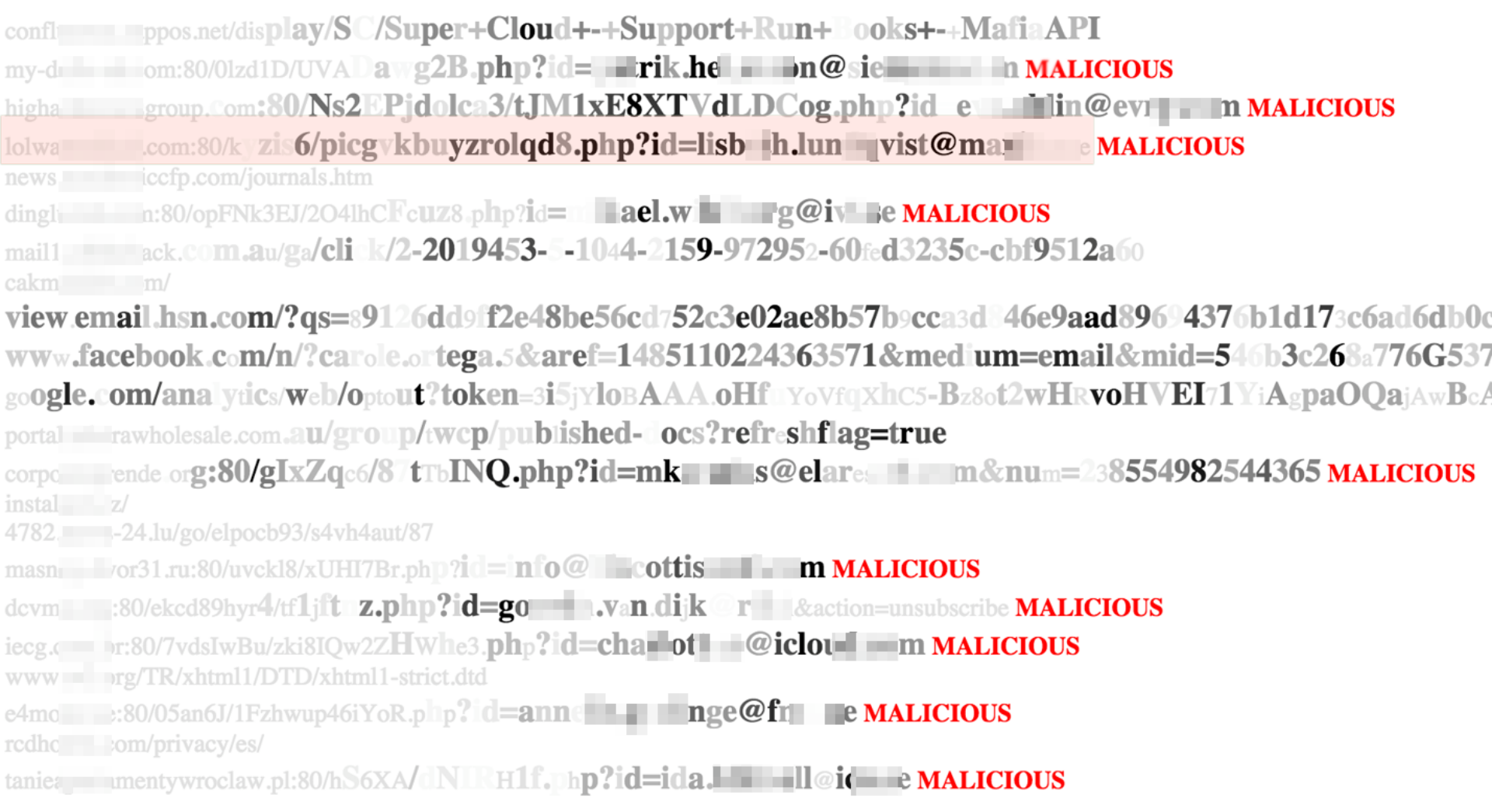
outputs/activations/image/4
run: run1/train
step **2580** (Fri Aug 25 2017 16:21:14 GMT+0800 (CST))



outputs/activations/image/5
run: run1/train
step **2580** (Fri Aug 25 2017 16:21:14 GMT+0800 (CST))

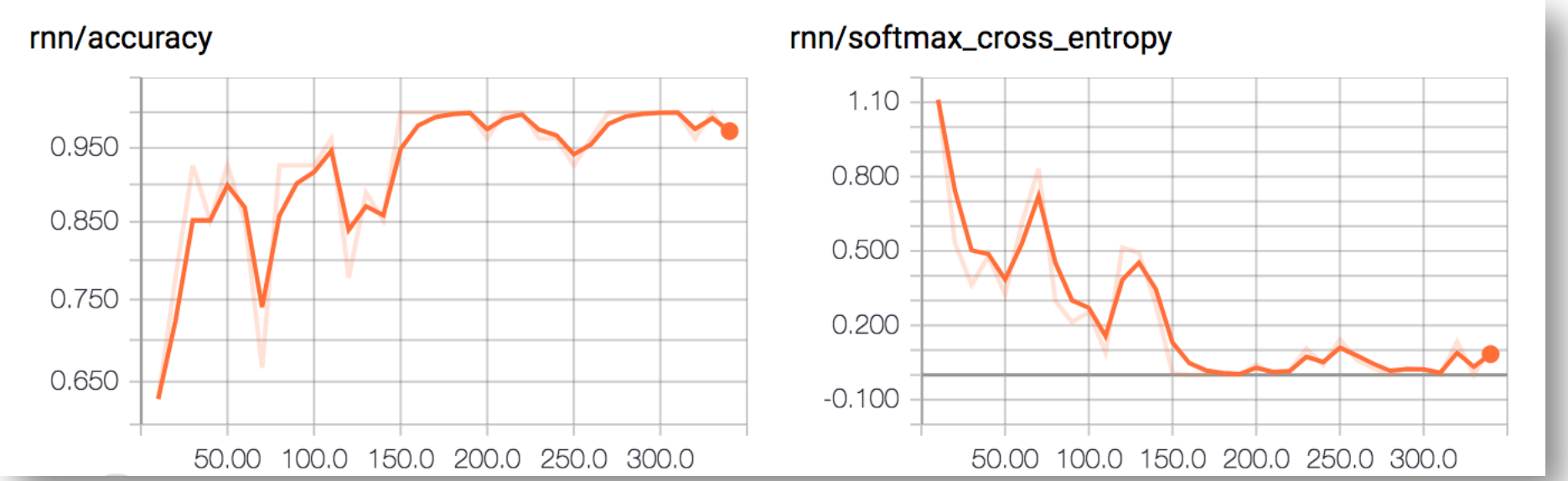


CryptoLocker URL detection using attention



Tensorboard

Accuracy & Cost



Experiment Summary

```
epoch 102 iteration 2492: cost 0.000037 (minibatch accuracy 100.000000%) [0 2 3]=[16  9  2]
epoch 102 iteration 2493: cost 0.000643 (minibatch accuracy 100.000000%) [0 2]=[ 4 23]
epoch 102 iteration 2494: cost 0.001896 (minibatch accuracy 100.000000%) [0 2]=[ 1 26]
epoch 102 iteration 2495: cost 0.000000 (minibatch accuracy 100.000000%) [0 1]=[ 3 24]
epoch 102 iteration 2496: cost 0.000000 (minibatch accuracy 100.000000%) [0 1]=[ 4 23]
epoch 102 iteration 2497: cost 0.000008 (minibatch accuracy 100.000000%) [0 2]=[ 6 21]
epoch 102 iteration 2498: cost 0.000000 (minibatch accuracy 100.000000%) [0]=[27]
epoch 102 step 99: validation accuracy 100.000000%
epoch 102 iteration 2499: cost 0.000000 (minibatch accuracy 100.000000%) [0]=[27]
epoch 102 iteration 2500: cost 0.000000 (minibatch accuracy 100.000000%) [0 1]=[18  9]
Training finished in 2813.9s
Best validation accuracy 100.000000%
Optimization complete with best validation accuracy 100.000000%
Training finished 2500 iterations in 2813.90 sec
validation accuracy 100.000000%
last_hidden_state.train: shape (2700, 64)
prediction: shape (2700, 4)
embedding metadata path: last_hidden_state.train.tsv
last_hidden_state.validation: shape (2700, 64)
prediction: shape (2700, 4)
embedding metadata path: last_hidden_state.validation.tsv
saving checkpoint iteration 0
```

Is it perfect?

- Undetected URL from test-cryptolocker.txt

```
www.leriov.com:80/leriov3/player1.php?id=aH!
BeF0cHM6Ly9waG90b3MuZ29vZ2xlLmNvbS9zaGFyZS9B!BeFjF!
BeFaXBNOHB!BeFcmplbEEydU!BeFPX3ZZQTBLel!
BeFKdjNmWVItMUFaM1UxQ1UtX25oWDho!BeFjNTaDh!
BeFaEs0bF85WXNlYVVySUNBP2tleT1NMDV3YjB!
BeFelNtVXpj@bfgo2TFdKVk1YQX!
BeFjWHBOY0VKdGFFdElhMHBS&id2=
```

- Analysis

This URL was misplaced in the test cryptolocker sample list. So this missed detection is a correct behaviour.

Towards Production

- Training and Testing by the samples