USING ML FOR GENERATING CRYPTOGRAPHIC FUNCTIONS

A PREPRINT

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ABSTRACT

TODO: read and review In this paper we unite machine learning and cryptography: using ML methods trying to solve one of the most important problem in cryptography: to find boolean function with acceptable cryptological properties. Neural network for making pseudorandom function is developed. This function used as round function in Feistel Network, which we finally test on NIST test battery.

***K*eywords** Cryptography · Machine Learning · Reinforcement Learning · Privacy

1 Introduction

TODO: read and review Cryptography is widely used in information security. Everyone is using it in messagers, shops, in internet of things and many others aspects of life. Many users encrypt its personal data without even knowing what cryptography is.

There are a lot of basic templates for cryptographic encryption functions called schemes - Feisteil network, SP-network, XSL-scheme etc. Every scheme has adjustable set of parameters such as plaintext and key size, internal round functions, number of rounds. Best practice in constructing new encryption algorithm is to choose a good scheme, then select perfect parameters of chosen scheme. For example, algorithm AES is a XSL-scheme with choosen internal operations, including s-boxes.

Chosing excellent round functions in another part of cryptographic art. When new algorithm is published, researchers of whole world trying to find weakness in it. Besides, absence of attacks doesn't mean that algorithm is strong. Many people, besides, prefer concept of «nothing up my sleeve numbers» [**?**], which require generating s-boxes only by random choise. Otherwise one can say that you try to hide specific propeties of your algorithm.

On the other hand, ML methods can be applying as approach to find a good

That's why in this paper we use neuronal network for generating good round function for Feisteil Network - one of the most popular scheme. Then we test properties of our algorithm on the NIST test battery.

2 Symmetric encryption basics

TODO...

[*]Use footnote for providing further information about author (webpage, alternative address)—*not* for acknowledging funding agencies.

3 Problem statement

TODO: read and review From ancient times to nowadays many different types of cryptographic attacks were presented. That's why cypher's developers very carefully selected cypher's parameters. Widely distributed (but, obviously, not absolutily reliable) method of proving new cipher's security is trying to apply to it all known attacks. Impossibility of applying all these attacks with acceptable time and data complexity gives grounds to consider the cipher as stable one.

This method has a lot of obvious defects. On the one hand, many variety of new attacks developed every year (and not all of them are published). On the other hand, when developer examined cipher made himself, he could miss some cipher's vulnerability. So you cannot say about absolute security.

Another look for cipher's security if to make its encryption function indistinguishable from random substitution.

4 Reinforcement Learning

TODO...

5 Solution

5.1 Main idea

TODO: (general words about combining encryption and ML)...

5.2 Feisteil Network

TODO: read and review For our experiments we chose the Feisteil Network scheme. This scheme first published in []. It uses in previous international standard DES [] and present widely used algorithm GOST28147-89 []. Now we'll give a brief discription of the scheme.

Denote $X = (x_n, x_{n-1}, \dots, x_0), x_i \in \{0, 1\}, i = 0, 1, \dots, n-1$ as input text, and n as (so, also a cipher text) size.

One *round* of the scheme is to modify input text $X = (X_l, X_r)$ to

$$(X_r, X_l \oplus f(X_r, k)).$$

Scheme has fixed number of rounds, which we denote as R. Input of first round is the input text. For other rounds input is the output of previous round. Cipher text is the output of the last (R-th) round.

then modify right part X_r with function $f : V_{n/2} \to V_{n/2}$ and round key $k \in V_{n/2}$.

TODO: in our experiments we used the following settings: Block size - 64 bit (2 x 32) Rounds number - 16

5.3 Neural network architecture

TODO... Deep fully connected network (8 layers), activation function - SELU Stochastic computation graph

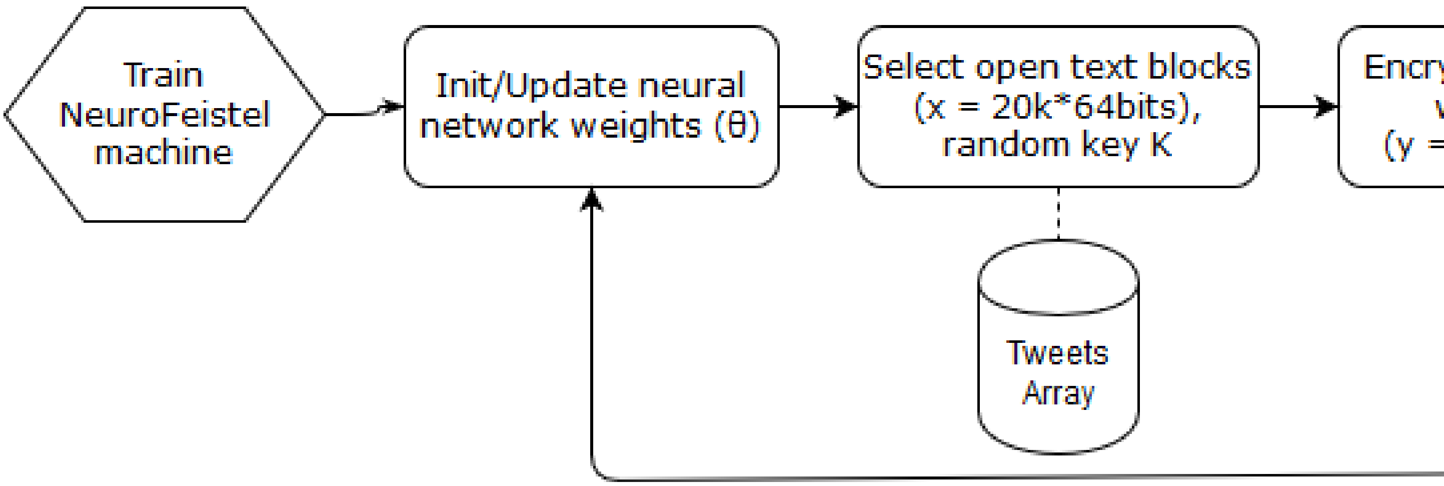
5.4 Optimization approach

TODO (Stochastic Policy Gradients, REINFORCE???)...

5.5 Reward function

TODO... consists of 3 components, each corresponding to a class of well-known attacks on cryptographic functions: Attack on related open texts Attack on related keys Attack on related encrypted texts

5.6 Putting pieces together

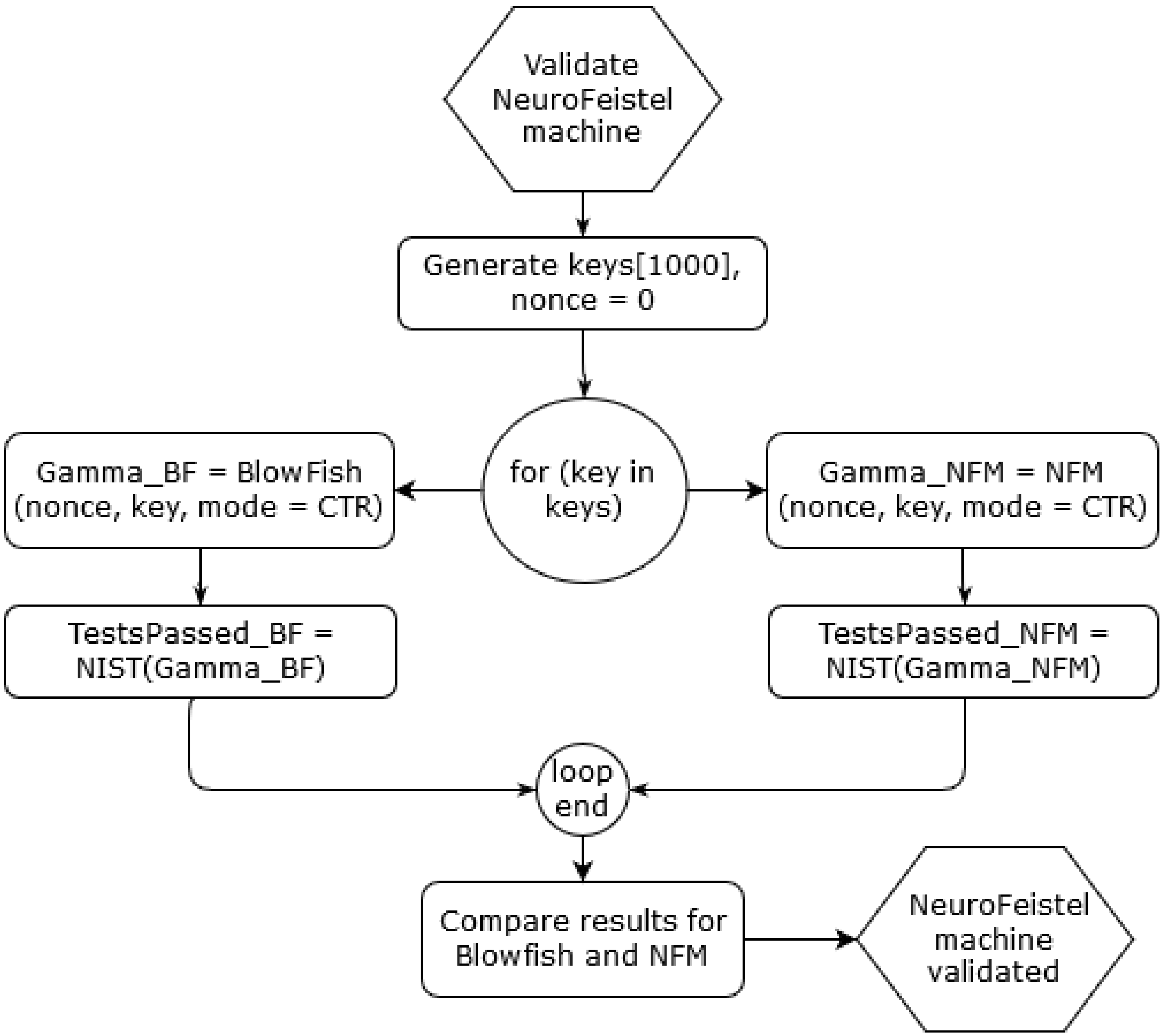


6 Experiments

6.1 Test methodology

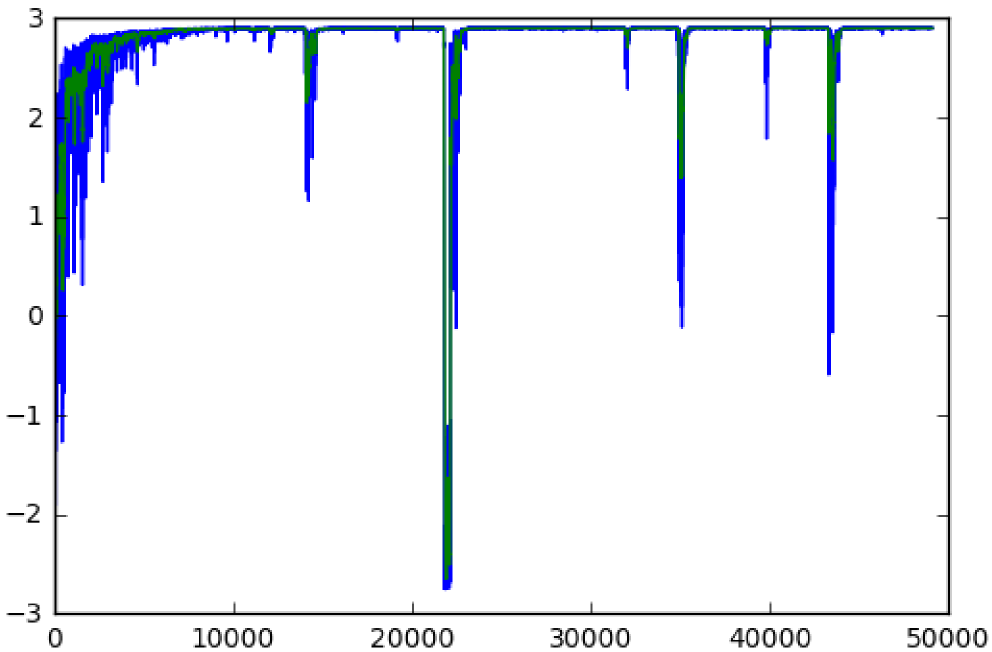
TODO... Input text data - 10 million Twitter messages Randomly generated round keys

6.2 Validation

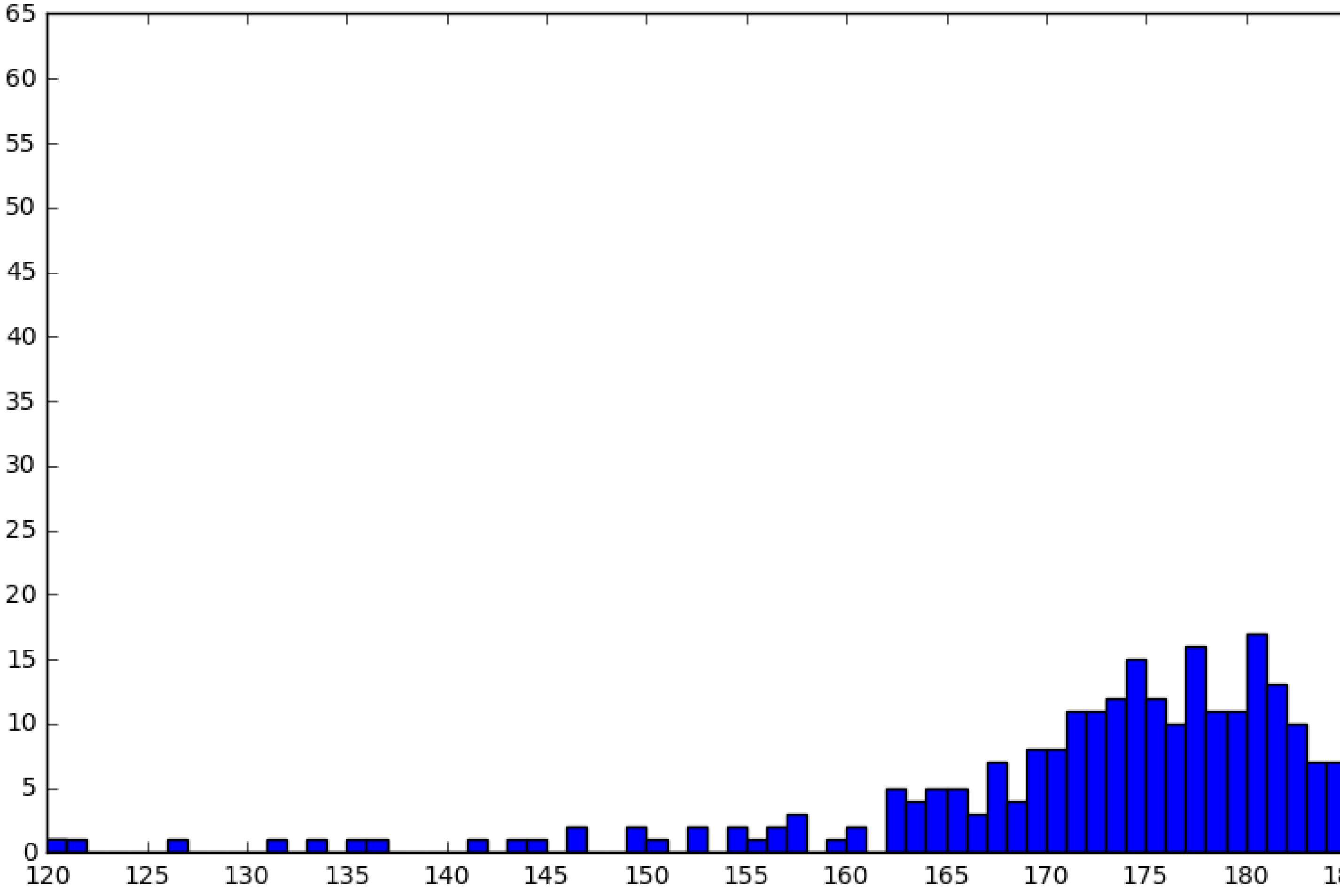


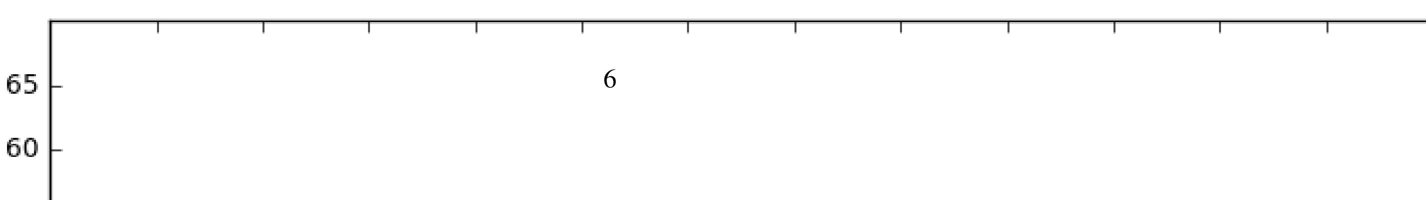
TODO...

6.3 Results



TODO...





7 Thoughts on further development

TODO...

8 Conclusion

TODO...