**Detect Breast Cancer Using Artificial Neural Networks**

**Introduction:**

Breast cancer is growing at an alarming rate. In US 1 out 8 women’s have a risk of developing breast cancer in their life. Breast cancer is a complicated disease to diagnose and rectify. It can be cured if detected on early stage. So we need an accurate and robust process to detect breast cancer.

Wisconsin Breast Cancer Database (WBCD) contains the data of various breast cancer cases. In this data, cases are categorized in two types (malignant and benign).

Wisconsin Breast Data Set:

Data consists of 11 attributes. First attribute contains the id of patient.

From attribute 2 to 10 contains different properties for detection of breast cancer ranging values from 1 to 10.

|  |  |  |
| --- | --- | --- |
| No | Attribute | Domain |
| 1 | Clump thickness | 1 – 10 |
| 2 | Uniformity of cell size | 1 – 10 |
| 3 | Uniformity of cell shape | 1 – 10 |
| 4 | Marginal adhesion | 1 – 10 |
| 5 | Single epithelial cell | 1 – 10 |
| 6 | Bare nuclei | 1 – 10 |
| 7 | Bland chromatin | 1 – 10 |
| 8 | Normal nucleoli | 1 – 10 |
| 9 | Mitosis | 1 – 10 |
|  | Class | 2 for benign, 4 for malignant |

Data set does contain some missing values.

We replace these values with median of that instance. For example bare nuclei has some missing values. We will take the median of that instance and replace missing values with it.

We will use Wisconsin data to train a network which will be able to characterize between malignant and benign cancer.

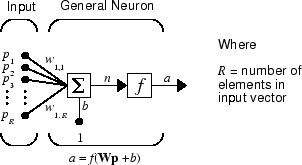
**Multilayer Neural Network Architecture:**

Now a days artificial neural networks (ANN’s) has been widely used to solve computation extensive and classification problems.

Multilayer neural network is a feedforward network consists of neurons.

**Neuron Model:**

It follows the brain neuron model to simulate the process. It can take one or more inputs and sums them to produce an output. It can use any differential transfer function to conjure output.



Multilayer networks often use log-sigmoid (logsig), tan-sigmoid (tansig) and linear (pureline) transfer functions.

Log-sigmoid and tan-sigmoid are used to solve pattern recognition problems. While pureline is used to solve linearly separable problems

*Log-sigmoid:*

Input: Positive infinity to negative infinity.

Output: 0 to 1

*Tan-sigmoid:*

Input: Positive infinity to negative infinity.

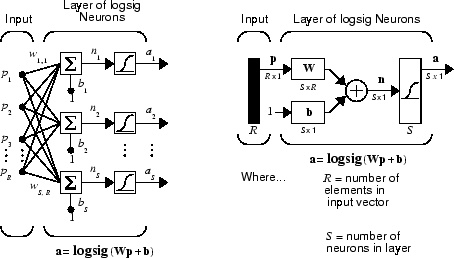
Output: 1 to -1

*Linear transfer function:*

Input and output ranges in positive to negative infinity.

**Feedforward Neural Network:**

Feedforward neural network consists (possibly) of multiple neurons.



**Hypothesis:**

**1: Changing no of layers will affect the performance of neural network.**

We have to classify the cancer in two forms which are malignant and benign. So I think that our problem can be solved with three layered neural network and it will give us the best result. As it can easily cover meshed regions.

*Experiment 1:*

Let’s first test with one layer:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hidden Layers | Data type | Training data | Testing Data | MSE |
| 1 | Unformatted | 1-400 | 401-699 | 4.68% |

*Experiment 2:*

Train a neural network with three hidden layers:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hidden Layers | Data type | Training data | Testing Data | MSE |
| 3 | Unformatted | 1-400 | 401-699 | 1.34% |

Experiment 3:

Now I’m going to double hidden layers to check whether it increases the error or not.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hidden Layers | Data type | Training data | Testing Data | MSE |
| 6 | Unformatted | 1-400 | 401-699 | 3.011% |

As you can see that MSE also increase with hidden layers.

Experiment 4:

Let’s further increase hidden layers to 9 to observe whether it affects the MSE or not.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hidden Layers | Data type | Training data | Testing Data | MSE |
| 9 | Unformatted | 1-400 | 401-699 | 2.0087% |

Well the result of these experiments are changing arbitrarily. Yet it is difficult to make a final statement. So let’s have another experiment:

Experiment 5:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hidden Layers | Data type | Training data | Testing Data | MSE |
| 12 | Unformatted | 1-400 | 401-699 | 3.011% |

Changing hidden layers are resulting in random MSE. But we have achieved the best result in three (Experiment 2) layers so far.

My hypothesis was a little bit vague, because I didn’t clearly mentioned that when we will achieve the best performance. As clear from the experiments that no. of layers does effect the performance but it can vary with the problem.

**2: Increasing the training data will decrease MSE.**

If I increase the training dataset error will decrease.

Experiment 1:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hidden Layers | Data type | Training data | Testing Data | MSE |
| 3 | Unformatted | 1-600 | 601-699 | 1% |

Experiment 2:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hidden Layers | Data type | Training data | Testing Data | MSE |
| 3 | Unformatted | 1-300 | 301-699 | 3.5% |

With decrease in training data increases the error.

Experiment 3:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hidden Layers | Data type | Training data | Testing Data | MSE |
| 3 | Unformatted | 1-200 | 201-699 | 3.005% |

Every time a network is created, it had different weights. This result in different output.

Experiment 4:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hidden Layers | Data type | Training data | Testing Data | MSE |
| 3 | Unformatted | 1-500 | 501-699 | 1.0075% |

As observed from previous experiments that increasing the training data result in better accuracy.

**Experimental Detail:**

Used MATLAB for conducting experiments. MATLAB provides nntool for such experiments.

# References

*Mathworks*. (2017, 12 3). Retrieved from Multilayer Neural Network: https://www.mathworks.com/help/nnet/ug/multilayer-neural-network-architecture.html

*US Breast Cancer Statistics* . (2017, 12 3). Retrieved from breastcancer.org: http://www.breastcancer.org/symptoms/understand\_bc/statistics

*Wikipedia*. (2017, 12 3). Retrieved from Artificial neuron: https://en.wikipedia.org/wiki/Artificial\_neuron

Gavin Brown. [Diversity in Neural Network Ensembles](http://rexa.info/paper/dd4500e327a5f555d2f594711dc50b0f9faccd30). The University of Birmingham. 2004. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#dd4500e327a5f555d2f594711dc50b0f9faccd30)].  
  
Krzysztof Grabczewski and Wl/odzisl/aw Duch. [Heterogeneous Forests of Decision Trees](http://rexa.info/paper/b19579eae108f0efb0d9adf97e480280f8e4f7a8). ICANN. 2002. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#b19579eae108f0efb0d9adf97e480280f8e4f7a8)].  
  
András Antos and Balázs Kégl and Tamás Linder and Gábor Lugosi. [Data-dependent margin-based generalization bounds for classification](http://rexa.info/paper/3ecc983417b61977b8f998e8a843948dad8fa21c). Journal of Machine Learning Research, 3. 2002. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#3ecc983417b61977b8f998e8a843948dad8fa21c)].  
  
Kristin P. Bennett and Ayhan Demiriz and Richard Maclin. [Exploiting unlabeled data in ensemble methods](http://rexa.info/paper/ca3e1e0bf335a97cedb76be7b64610181e0f6684). KDD. 2002. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#ca3e1e0bf335a97cedb76be7b64610181e0f6684)].  
  
Hussein A. Abbass. [An evolutionary artificial neural networks approach for breast cancer diagnosis](http://rexa.info/paper/3a500f9d0b3bfdadc810cde1043178b2d127888e). Artificial Intelligence in Medicine, 25. 2002. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#3a500f9d0b3bfdadc810cde1043178b2d127888e)].  
  
Baback Moghaddam and Gregory Shakhnarovich. [Boosted Dyadic Kernel Discriminants](http://rexa.info/paper/4ce4c96181e2836dd80a71c2efebc7fb030c55d8). NIPS. 2002. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#4ce4c96181e2836dd80a71c2efebc7fb030c55d8)].  
  
Robert Burbidge and Matthew Trotter and Bernard F. Buxton and Sean B. Holden. [STAR - Sparsity through Automated Rejection](http://rexa.info/paper/c185d513badef2336ca48f64098d4b5df17bf5a4). IWANN (1). 2001. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#c185d513badef2336ca48f64098d4b5df17bf5a4)].  
  
Nikunj C. Oza and Stuart J. Russell. [Experimental comparisons of online and batch versions of bagging and boosting](http://rexa.info/paper/5193dfc0a9d39b5f86fe360d6beff81aa9b7390e). KDD. 2001. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#5193dfc0a9d39b5f86fe360d6beff81aa9b7390e)].  
  
Yuh-Jeng Lee. [Smooth Support Vector Machines](http://rexa.info/paper/3c3eb7beca3f6ab6fcebe2863131fa3dbae6cb7f). Preliminary Thesis Proposal Computer Sciences Department University of Wisconsin. 2000. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#3c3eb7beca3f6ab6fcebe2863131fa3dbae6cb7f)].  
  
Justin Bradley and Kristin P. Bennett and Bennett A. Demiriz. [Constrained K-Means Clustering](http://rexa.info/paper/93e4d326f6a322d66e034c1b88773f3a7f621526). Microsoft Research Dept. of Mathematical Sciences One Microsoft Way Dept. of Decision Sciences and Eng. Sys. 2000. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#93e4d326f6a322d66e034c1b88773f3a7f621526)].  
  
Lorne Mason and Peter L. Bartlett and Jonathan Baxter. [Improved Generalization Through Explicit Optimization of Margins](http://rexa.info/paper/63e63c88edc486c3b1b2aeebb790f88a119536c9). Machine Learning, 38. 2000. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#63e63c88edc486c3b1b2aeebb790f88a119536c9)].  
  
P. S and Bradley K. P and Bennett A. Demiriz. [Constrained K-Means Clustering](http://rexa.info/paper/d254374dd5eab5d871c8010dcbe4ac84ec86ea8c). Microsoft Research Dept. of Mathematical Sciences One Microsoft Way Dept. of Decision Sciences and Eng. Sys. 2000. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#d254374dd5eab5d871c8010dcbe4ac84ec86ea8c)].  
  
Endre Boros and Peter Hammer and Toshihide Ibaraki and Alexander Kogan and Eddy Mayoraz and Ilya B. Muchnik. [An Implementation of Logical Analysis of Data](http://rexa.info/paper/7265efd898e4c045ff078fcb63fec9fbde4b1249). IEEE Trans. Knowl. Data Eng, 12. 2000. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#7265efd898e4c045ff078fcb63fec9fbde4b1249)].  
  
Chun-Nan Hsu and Hilmar Schuschel and Ya-Ting Yang. [The ANNIGMA-Wrapper Approach to Neural Nets Feature Selection for Knowledge Discovery and Data Mining](http://rexa.info/paper/283e535d8f512eedabbd803c72a86b891eed8474). Institute of Information Science. 1999. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#283e535d8f512eedabbd803c72a86b891eed8474)].  
  
Huan Liu and Hiroshi Motoda and Manoranjan Dash. [A Monotonic Measure for Optimal Feature Selection](http://rexa.info/paper/73cfbd8185405d37df94492642c9ffdb3b48c37f). ECML. 1998. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#73cfbd8185405d37df94492642c9ffdb3b48c37f)].  
  
Lorne Mason and Peter L. Bartlett and Jonathan Baxter. [Direct Optimization of Margins Improves Generalization in Combined Classifiers](http://rexa.info/paper/271b9c67f2a11a31962a436a41aaa5ed148dda6e). NIPS. 1998. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#271b9c67f2a11a31962a436a41aaa5ed148dda6e)].  
  
W. Nick Street. [A Neural Network Model for Prognostic Prediction](http://rexa.info/paper/79b9012d7063a4c0e98d98ebd63d63044c8da997). ICML. 1998. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#79b9012d7063a4c0e98d98ebd63d63044c8da997)].  
  
Yk Huhtala and Juha Kärkkäinen and Pasi Porkka and Hannu Toivonen. [Efficient Discovery of Functional and Approximate Dependencies Using Partitions](http://rexa.info/paper/ac8fe867e1d16d4d09f9bd759ba46699055c7ca6). ICDE. 1998. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#ac8fe867e1d16d4d09f9bd759ba46699055c7ca6)].  
  
Kristin P. Bennett and Erin J. Bredensteiner. [A Parametric Optimization Method for Machine Learning](http://rexa.info/paper/63ebbe51c9c4dea76320f7b6a40f2a59f10cc7c0). INFORMS Journal on Computing, 9. 1997. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#63ebbe51c9c4dea76320f7b6a40f2a59f10cc7c0)].  
  
Rudy Setiono and Huan Liu. [NeuroLinear: From neural networks to oblique decision rules](http://rexa.info/paper/c2525357aa81ca73fb410a5013d47e3c6931342b). Neurocomputing, 17. 1997. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#c2525357aa81ca73fb410a5013d47e3c6931342b)].  
  
. [Prototype Selection for Composite Nearest Neighbor Classifiers](http://rexa.info/paper/b0009a0081cc5fbfbae758def55cfd5b3256623b). Department of Computer Science University of Massachusetts. 1997. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#b0009a0081cc5fbfbae758def55cfd5b3256623b)].  
  
Erin J. Bredensteiner and Kristin P. Bennett. [Feature Minimization within Decision Trees](http://rexa.info/paper/7d8a7f4c9a24d1127a5ded21969c82ed63037c42). National Science Foundation. 1996. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#7d8a7f4c9a24d1127a5ded21969c82ed63037c42)].  
  
Ismail Taha and Joydeep Ghosh. [Characterization of the Wisconsin Breast cancer Database Using a Hybrid Symbolic-Connectionist System](http://rexa.info/paper/9f9df113476ffbf356892bb497bd2714e6f56d99). Proceedings of ANNIE. 1996. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#9f9df113476ffbf356892bb497bd2714e6f56d99)].  
  
Jennifer A. Blue and Kristin P. Bennett. [Hybrid Extreme Point Tabu Search](http://rexa.info/paper/19e1b6e0932bbe665a2c4a069a0636d8d5cf0c6f). Department of Mathematical Sciences Rensselaer Polytechnic Institute. 1996. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#19e1b6e0932bbe665a2c4a069a0636d8d5cf0c6f)].  
  
Geoffrey I. Webb. [OPUS: An Efficient Admissible Algorithm for Unordered Search](http://rexa.info/paper/81a75649d5acc1cc428ca756dac221bac3c8fe01). J. Artif. Intell. Res. (JAIR, 3. 1995. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#81a75649d5acc1cc428ca756dac221bac3c8fe01)].  
  
Rafael S. Parpinelli and Heitor S. Lopes and Alex Alves Freitas. [An Ant Colony Based System for Data Mining: Applications to Medical Data](http://rexa.info/paper/899bdb470e48c308144216cc22048c88816ee035). CEFET-PR, CPGEI Av. Sete de Setembro, 3165. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#899bdb470e48c308144216cc22048c88816ee035)].  
  
Wl/odzisl/aw Duch and Rafal/ Adamczak Email:duchraad@phys. uni. torun. pl. [Statistical methods for construction of neural networks](http://rexa.info/paper/53ac23f963b3607aae9580b356e6b236d2955314). Department of Computer Methods, Nicholas Copernicus University. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#53ac23f963b3607aae9580b356e6b236d2955314)].  
  
Rafael S. Parpinelli and Heitor S. Lopes and Alex Alves Freitas. [PART FOUR: ANT COLONY OPTIMIZATION AND IMMUNE SYSTEMS Chapter X An Ant Colony Algorithm for Classification Rule Discovery](http://rexa.info/paper/f4405e32dbb5dea3ece303e2a5b3edb6b413271e). CEFET-PR, Curitiba. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#f4405e32dbb5dea3ece303e2a5b3edb6b413271e)].  
  
Adam H. Cannon and Lenore J. Cowen and Carey E. Priebe. [Approximate Distance Classification](http://rexa.info/paper/095d7064837557bdfbca12fb9c12dbaaeb3a8b0d). Department of Mathematical Sciences The Johns Hopkins University. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#095d7064837557bdfbca12fb9c12dbaaeb3a8b0d)].  
  
Andrew I. Schein and Lyle H. Ungar. [A-Optimality for Active Learning of Logistic Regression Classifiers](http://rexa.info/paper/b0bf518f2c1c4ab72ebac0d17757aa8f52a6badf). Department of Computer and Information Science Levine Hall. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#b0bf518f2c1c4ab72ebac0d17757aa8f52a6badf)].  
  
Bart Baesens and Stijn Viaene and Tony Van Gestel and J. A. K Suykens and Guido Dedene and Bart De Moor and Jan Vanthienen and Katholieke Universiteit Leuven. [An Empirical Assessment of Kernel Type Performance for Least Squares Support Vector Machine Classifiers](http://rexa.info/paper/dba0c3d458498a4eef66d37b0f3b1cb310086d31). Dept. Applied Economic Sciences. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#dba0c3d458498a4eef66d37b0f3b1cb310086d31)].  
  
Adil M. Bagirov and Alex Rubinov and A. N. Soukhojak and John Yearwood. [Unsupervised and supervised data classification via nonsmooth and global optimization](http://rexa.info/paper/50b9babac023b426f1531a4265076bea534d121e). School of Information Technology and Mathematical Sciences, The University of Ballarat. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#50b9babac023b426f1531a4265076bea534d121e)].  
  
Rudy Setiono and Huan Liu. [Neural-Network Feature Selector](http://rexa.info/paper/9a75a9a8ce786d6a05ad51afa124cd4f70bfbb36). Department of Information Systems and Computer Science National University of Singapore. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#9a75a9a8ce786d6a05ad51afa124cd4f70bfbb36)].  
  
Huan Liu. [A Family of Efficient Rule Generators](http://rexa.info/paper/8f5ae7219e74a85e3f722b58b3fedb30eab7a1d7). Department of Information Systems and Computer Science National University of Singapore. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#8f5ae7219e74a85e3f722b58b3fedb30eab7a1d7)].  
  
Rudy Setiono. [Extracting M-of-N Rules from Trained Neural Networks](http://rexa.info/paper/42ba5137ab9d88dc1eae5caac18cb6a1818ae700). School of Computing National University of Singapore. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#42ba5137ab9d88dc1eae5caac18cb6a1818ae700)].  
  
Jarkko Salojarvi and Samuel Kaski and Janne Sinkkonen. [Discriminative clustering in Fisher metrics](http://rexa.info/paper/705b438dbe9ed18fe23005c774d2993019da030f). Neural Networks Research Centre Helsinki University of Technology. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#705b438dbe9ed18fe23005c774d2993019da030f)].  
  
Wl odzisl and Rafal Adamczak and Krzysztof Grabczewski and Grzegorz Zal. [A hybrid method for extraction of logical rules from data](http://rexa.info/paper/c3f9c3303aa080beec901b74703cef88ee2b2f24). Department of Computer Methods, Nicholas Copernicus University. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#c3f9c3303aa080beec901b74703cef88ee2b2f24)].  
  
Charles Campbell and Nello Cristianini. [Simple Learning Algorithms for Training Support Vector Machines](http://rexa.info/paper/b6e169d69cd67763b95698e8961696fec9ca93bf). Dept. of Engineering Mathematics. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#b6e169d69cd67763b95698e8961696fec9ca93bf)].  
  
Chotirat Ann and Dimitrios Gunopulos. [Scaling up the Naive Bayesian Classifier: Using Decision Trees for Feature Selection](http://rexa.info/paper/4695569c53cd581fcc193415a8a94a1f92abf607). Computer Science Department University of California. [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#4695569c53cd581fcc193415a8a94a1f92abf607)].  
  
Wl odzisl/aw Duch and Rudy Setiono and Jacek M. Zurada. [Computational intelligence methods for rule-based data understanding](http://rexa.info/paper/8afa6796645ce4b0642db26c822cf6bfa8cc4d0d). [[View Context](http://archive.ics.uci.edu/ml/support/Breast+Cancer+Wisconsin+(Original)#8afa6796645ce4b0642db26c822cf6bfa8cc4d0d)].