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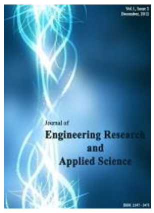

Machine Learning (ML) for Artillery War Strategic Readiness Prediction, and Postmortem Analysis for Optimum Performance

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Abstract
Computer soft-ware based-tool, a tool to process data that produces accurate results and does not make mistakes like human beings. Based on its efficient storage to secure and protect information stored inside it as well as fast access to information stored. These qualities were needed as aids for artillery war strategic readiness prediction, and postmortem analysis for optimum performance achievement already developed by the authors of this article. Hence, the development of Machine Learning (ML) which is a branch of artificial intelligence (AI) that focused on enabling computers and machines to imitate the way that humans learn, to perform tasks autonomously, and to improve their performance and accuracy through experience and exposure to more data. The Problem was defined, the data used in the manual computation were collected, the right algorithm was developed using Python Programming Language, the data were split, the develop model was trained, the models were evaluated and optimized before being deployed. The results were found to be exactly the same as the manually computed results of Akinnuli *et al* [2]. This Machine Learning successfully predicts the case studied artillery level of readiness for an operation at this point in time as **74%** and the risk involved (that is unreadiness) as **26%.** The score of this case study was 233 out of 315 points. The score is Less than 248 but greater than 186 which fell into "**Scenario C"** of Decision Conditions (**$248 > SDS_p \geq 186$**). The quantitative assessment is **(Good).** Time used for manual computation was one hour twenty minutes (1Hr. 20 Minutes) that is eighty minutes (80 minutes) while computer used fifteen (15) minutes, data input time and processing time added for these computations. This is a very good saving time of sixty-five (65) minute. Comparing the Machine Learning results with the manually computed results Statistic correlation model (**Product moment coefficient of correlation (r))** was used to prove the reliability of the developed ML algorithm. The correlation r = 1.0071 (Approximately r = **1.00)** which shows that it is strong positive perfect correlation. This is scientific base that gave approval for deployment of the Machine Learning algorithm developed for its artillery corps usage.

Keywords: *Machine learning, artillery war strategies, readiness prediction model, war postmortem analysis, performance optimization.*

1. Introduction
In the current age of the Fourth Industrial Revolution (4IR or Industry 4.0), the digital world has a wealth of data, such as Internet of Things (IoT) data, cybersecurity data, mobile data, business data, social media data, health data, etc. To intelligently analyze these data and develop the corresponding smart and automated applications, the knowledge of artificial intelligence (AI), particularly, machine learning (ML) is the key [17].

Geza, worked on Potential Role of Artificial Intelligence in the Development of Field Artillery The article, after a short theoretical explanation, examines the role that artificial intelligence can play in the development of different areas of field artillery (artillery target acquisition, fire control systems, weapons and ammunition) [15]. At the end of the study, the author draws attention to an area that is still quite undeveloped today, the ethical issues of the use of artificial intelligence. Long and Qian, solve the problems of confusing concepts and uncertain technologies in the development of intelligent artillery, this paper proposed to study intelligent artillery from the perspective of intelligent engineering concept [10, 19]. First, the concept of intelligent artillery engineering was explained, and the scientific ideas and methods of intelligent artillery research were defined.

Detection and mapping of artillery craters with very high spatial resolution satellite imagery and deep

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learning were authored by Achanta et al [1]. While Satellite analysis of the environmental impacts of armed-conflict in Rakhine, and land-use change in the caucasus during and after the Nagorno-Karabakh conflict were the works of Aung [4] and Baumann *et al* [5]. Based on limited space available works of other authors relevant to this research are hereby summarized: Bennett *et al* [6] Improved satellite monitoring of armed conflicts Earth's Future, Deininger *et al* [11] Quantified war-induced crop losses in Ukraine in near real time to strengthen local and global food security. An unexpectedly large count of trees in the West African Sahara and Sahel. Nature was researched by Brandt *et al* [7]. The Putin's undeclared war of 2016 was researched by Case [8] where Russian Artillery Strikes against Ukraine. Cheng and Han [9], carried out a survey on object detection in optical remote sensing images Eun, and Skakun [12] did similar research. An artillery accuracy model was developed by Faan [14]. The research was used to characterized land use with night-time imagery using the war in Eastern Ukraine (2012–2016) as case study.

Gorsevski *et al* [16], analysed the Impacts of armed conflict on the Eastern Afromontane forest region on the South Sudan—Uganda border using multitemporal Landsat imagery. Simone *et al* [25], researched on "Sound of guns: digital forensics of gun audio samples using artificial intelligence," Audio event recognition in noisy environments using power spectral density and dimensionality reduction was carried out by Siddat *et al* [24], while Eva *et al* [13] authored "Gun type recognition from gunshot audio recordings," in 3rd international workshop on biometrics and forensics. Machine learning inspired efficient acoustic gunshot detection and localization system, and Automated detection of gunshots in tropical forests using convolutional neural networks", were the works of Muhammad *et al* [21] and Lydia *et al* [20] in this area, much research were done and published such as: John *et al* [18] , Zhicong *et al* [26], Rahu *et al* [23], Ali *et al* [3], and Rahul *et al* [23]. Weapon detection in real-time cctv videos using deep learning research was done by Mohammed *et al* [22]. The literature reviewed so far showed gap in literature of non-existence of Machine Learning (ML) for artillery war strategic readiness prediction, and postmortem analysis for optimum performance.

2. Methodology

2.1. Strategic Decision for Artillery Defense Plan

The required strategic decision gathered from experienced artillery commanders and literature review of advanced countries as United State of America, United Kingdom, France, Germany and China were hereby stated by Akinnuli *et al* [2]:

(a) Combat operation center security **(A).**
(b) Avoid detection **(B)**.
(c) Conduct terrain analysis **(C)**.
(d) Provision of Early Warming (D).
(e) Make defensive preparation **(E)**.
(f) Executive defensive actin **(F).**
(g) Active and passive defense measure **(G).**
(h) Signals **(H).**
(i) Reconstituting of Unit **(J).**
(j) Special considerations for command elements **(K)**.

2.2. Mathematical Models

The developed models for this machine learning were adopted from Akinnuli *et al* [2].
These models were twenty six (26) in number. The required logic was generated using these models by integrating them to form the required logic for the Machine Learning algorithm. This logic is as shown in figure 1.

Each strategic decision contribution and attributes were assigned weighs in two steps following the completion of ordinal ranking. The simplest procedure used was ranking of 5 (Excellent), 4 (Very Good), 3(Good), 2(Fair) and 1(Poor) for each attribute based on position with higher numbers signifying greater importance.

2.3. Determination of Optimum Score

$\boldsymbol{FS_P = f\,(A, B, C, D, E, F, G, H, J, K_a, K_b, K_c)}$.

Final Score Points ($\boldsymbol{FS_P}$) = Sum [A, B, C, D, E, F, G, H, J, $\boldsymbol{K_a, K_b, K_c}$]

The optimum or highest point that can be made is 5(63) = 315 points which will make the artillery hundred percent (100%) ready for war [2].

2.3.1. Determination of Each Strategic Decision Readiness Final Score

This is achieved by dividing the total score points by summation method by Optimum point available.

$\boldsymbol{R_w = FS_p / OP_s = TS/ 315}$ [2].

Where $\mathbf{R_w}$ is the war readiness, $\boldsymbol{TS_p}$ is the total scored point and $\boldsymbol{OP_s}$ is the optimum available score points (which is 315 points).

2.3.2. Qualitative judgement scenarios

In order to make a well-defined qualitative decision on these, the following bench marks were set using strategic decision scores or points.

Scores or points:

A). Greater than or Equal to 279 of 315 (.> or =) 279 **(Excellent).** That is **($\boldsymbol{SDS_p \geq 279}$).**

B). Greater than or Equal to (> 248 or < 279) = **(Very Good).** That is **($\boldsymbol{248 < SPS_p < 279}$)**

C). Less than 248 or Equal to 186 (< 248 or = 186) = **(Good).** That is **(248 > SDS_p ≥ 186)**

D). Less than 186 or equal 125 (< 186 or = 125) = **Fair.** That is **(186 > SDS_p ≥ 125)**

E). Less than 124 (< 124) = **Poor.** That is **(SDS_p < 124)** [2]

2.4. Flow Chart for the Model Developed

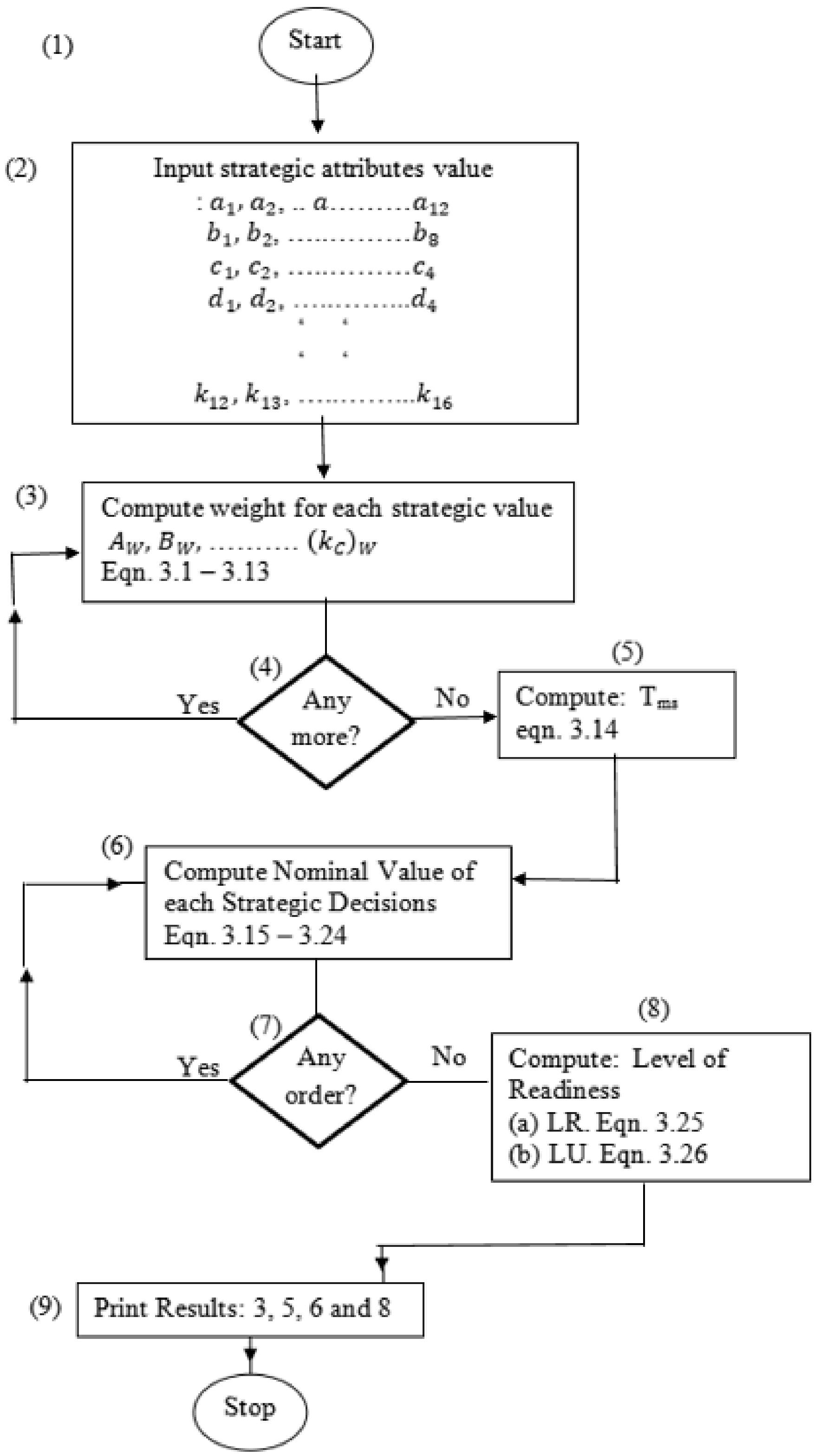

Figure 1. Algorithm Logic for the Machine Learning

2.5. Model Application

2.5.1. Data Mined for computations

The matrix table developed was used to collect the required data for assessment of war level of preparedness. Three Nations were contacted. Two turned down the request with the mind of keeping secrecy secrete only one assisted in filling this table after strong persuasion and conviction that information collected will only be limited to this research. The benefits of this academic work to them as developed Nation strong in artillery were well stressed. The data collected was as shown in the table 1.

Table 1: Developed Matrix Table for Strategic Decision / Attributes Score Records [2]

	Strategic Decision/Attributes	**Acronyms.**	**Excellent (5)**	**Very Good (4)**	**Good (3)**	**Fair (2)**	**Poor (1)**
A	**Target Acquisition Capability.**	**a_1- a_{12}**					
	Radio direction finding.	a_1	5				
	Counter Fire Radar	a_2		4			
	Flash /sound ranging	a_3		4			
	Visual detection from air or ground	a_4		4			
	Photographic and Thermal detection Devices	a_5		4			
	Night Observation Devices	a_6		4			
	Fire by Artillery or Mortars	a_7	5				
	Air Attack by fixed –or- Rotary-Wing Aircraft	a_8			3		
	Infantry Assault	a_9		4			
	Mechanized Assault	a_{10}	5				
	Infiltration and Sabotage	a_{11}			3		
	Jamming and Initiative Deception	a_{12}				2	
	SUM "A" = 60	**47**	**15**	**24**	**6**	**2**	**0**
B	**Avoid Detection**	**b_1- b_8**					
	Use of Camouflage	b_1	5				
	Reduce Electronic Signature	b_2		4			
	Main light and Noise Discipline	b_3		4			
	Reduced Weapons Signature	b_4			3		
	Established a Track Plan.	b_5	5				
	Use Dispersion.	b_6		4			
	Practice Communication Security.	b_7			3		
	Displace	b_8			3		
	SUM "B" = 40	**31**	**10**	**12**	**9**	**0**	**0**
C	**Conduct Terrain Analysis Using KOCOA**	**c_1- c_5**	**Excellent (5)**	**Very Good (4)**	**Good (3)**	**Fair (2)**	**Poor (1)**
	Key Terrain	c_1			3		
	Observation and Fields of Fire.	c_2			3		
	Cover and Concealment	c_3		4			
	Obstacles	c_4	5				
	Avenues of Approach.	c_5			3		
	SUM "C" = 25	**18**	**5**	**4**	**9**	**0**	**0**

D	**Provide Early Warning.**	**d_1- d_4**					
	Sentinel Posts and Listening Post	d_1		4			
	Patrols	d_2			3		
	Monitoring and Tactical Situation	d_3		4			
	Other Measures	d_4	5				
	SUM "D" = 20	**16**	**5**	**8**	**3**	**0**	**0**
E	**Make Defense Preparation.**	**e_1- e_7**					
	Organizing the Defense.	e_1		4			
	Defensive Diagram	e_2			3		
	Range Cards.	e_3				2	
	Fortifications and Obstacles.	e_4			3		
	Hardening of Positions.	e_5	5				
	Reaction Force	e_6		4			
	Coordinate with Adjacent Units Mutual Support	e_7				2	
	SUM "E" = 35	**23**	**5**	**8**	**6**	**4**	**0**
F	**Execute Defense Action.**	**f_1- f_3**					
	Can Repel / Sustain Attack	f_1		4			
	Cannot Repel or Sustain Attack	f_2			3		
	Preplanned Fire/Smoke	f_3		4			
	SUM "F" = 15	**11**	**0**	**8**	**3**	**0**	**0**
G	**Active and Passive Defense Measure.**	**$g_1 – g_2$**	**Excellent (5)**	**Very Good (4)**	**Good (3)**	**Fair (2)**	**Poor (1)**
	Active Defense	g_1		4			
	Passive Defense	g_2			3		
	SUM "G" = 10	**7**	**0**	**4**	**3**	**0**	**0**
H	**Signals**	**h_1 –h_3**					
	Defense against Air Attack.	h_1	5				
	NBC Defense.	h_2				2	
	Ground Attack.	h_3			3		
	SUM "H" = 15	**10**	**5**	**0**	**3**	**2**	**0**
J	**Reconstituting the Unit**	**$j_1 – j_4$.**					
	Report to Higher Headquarters	j_1	5				
	Radar First Aid and Evacuate Casualties	j_2		4			
	Assess Damage, repair Equipment, Redistribute Assets etc.	j_3			3		
	Deconterminate Personnel and Materials if Attacked by NBC	j_4			3		
	SUM "J" = 20	**15**	**5**	**4**	**6**	**0**	**0**
K	**Special Considerations for Command Elements,**	**$k_1 – k_{15}$**					
ka	**FWD COC**	**$k_1 – k_5$**					
	Mission and Task Assigned	k_1		4			
	Personnel Located at each side.	k_2	5				

	Vehicle and Other Section Equipment for Support Mission	k_3		4			
	Crew-Served Weapons Required for Adequate Protection	k_4			3		
	Fire Support Available	k_5		4			
	SUM “ka” = 25	**20**	**5**	**12**	**3**	**0**	**0**
k_b	**Main COC**	**$k_6 – k_{10}$**	**Excellent (5)**	**Very Good (4)**	**Good (3)**	**Fair (2)**	**Poor (1)**
	Mission and Task Assigned	k_6			3		
	Personnel Located at each side.	k_7			3		
	Vehicle and Other Section Equipment for Support Mission	k_8				2	
	Crew-Served Weapons Required for Adequate Protection	k_9	5				
	Fire Support Available	k_{10}		4			
	SUM “k_b” = 25	**17**	**5**	**4**	**6**	**2**	**0**
k_c	**LOGISTICAL TRAIN**	**$k_{11} – k_{15}$**					
	Mission and Task Assigned	k_{11}		4			
	Personnel Located at each side.	k_{12}			3		
	Vehicle and Other Section Equipment for Support Mission	k_{13}			3		
	Crew-Served Weapons Required for Adequate Protection	k_{14}		4			
	Fire Support Available	k_{15}		4			
	SUM “k_c” = 25	**18**	**0**	**12**	**6**	**0**	**0**

Source: [2]

Table 2. Computations results summary for discussions and decisions making.

S/N	**STRATEGIC DECISIONS**	**READINESS % (R%) (Total Score Points / Max. Score) 100**	**RISK % (1- R%)**
1	Target Acquisition Capability (A)	78.33%	21.67%
2	Avoid Detection (B)	77.50%	22.50%
3	Conduct Terrain Analysis Using KOCOA (C).	72.00%	***28.00%**
4	Provide Early Warning. (D).	80.00%	20.00%
5	Make Defense Preparation (E).	65.71%	***34.29%**
6	Execute Defense Action. (F).	73.33%	***26.67%**
7	Active and Passive Defense Measure. (G).	70.00%	***30.00%**
8	Signals (H).	66.66%	***33.34%**
9	Reconstituting the Unit (J).	75.00%	25.00%
10	FWD COC (K_a).	80.00%	20.00%
11	Main COC (K_b)	68.00%	***32.00%**
12	Logistical Train (K_c).	72.00%	***28.00%**
	AVERAGE READINESS AND RISK %	**74.00%**	**26.00%**

Source: [2]

Table 3. Product moment coefficient of correlation (r) of the readiness results in table 2.

SD	X (Manual Values).	Y (Computer Values)	X^2	Y^2	XY
A	71.66%	71.66324%	5135.1556	5135.6199672976	5135.3877784
B	77.50%	77.50116%	6006.2500	6006.4298013456	6006.3399000
C	72.00%	72.00125%	5184.0000	5184.1800015625	5184.0900000
D	80.00%	80.00164%	6400.0000	6400.2624026896	6400.1344000
E	65.71%	65.71011%	**4317.8041**	**4317.8185562121**	**4317.8113281**
F	73.33%	73.331134%	5377.2889	5374.5525725956	5377.3720562
G	70.00%	70.00402%	**4900.0000**	**4900.5628161604**	**4900.2814000**
H	66.66%	66.660011%	**4443.5556**	**4443.5570665201**	**4443.5563332**
J	75.00%	75.00015%	5625.0000	5625.0225000225	5625.0112500
Ka	80.00%	80.00213%	6400.0000	6400.3408045369	6400.1704000
Kb	68.00%	68.00100%	**4624.0000**	**4624.1360010000**	**4624.0680000**
Kc	72.00%	72.00146%	5184.0000	5184.2102421316	5184.10512
	∑X = 871.86	**∑ Y = 871.877305**	**∑ X^2 = 63597.0542**	**∑ Y^2 = 63596.6927775181**	**∑ XY = 63598.6500561432**

Correlation Coefficient Formulas and Application.

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{n\sum x^2 - (\sum x)^2} \times \sqrt{n\sum y^2 - (\sum y)^2}}$$

Where : n is 12;

$$\sum x \ is\ 871.86$$

$$\sum y \ is\ 871.877305$$

$$\sum x^2 \ is\ 63597.0542$$

$$\sum y^2 \ is\ 63596.6927775181$$

$$\sum xy \ is\ 63598.6500561432$$

respectively.

r = 3028.853541418 / 3007.485055688
r = 1.0071 (Approximately r = 1
r = **1.00** (positively perfect correlation).

This is scientific base that gave approval for deployment of the Machine Learning algorithm developed for its artillery corps military usage.

2.6. Developed Computer Software Interface and Applications

In order to get this model easily and friendly used, reduced error and burden of manual computations, a computer software-based tool was developed using Python programming language for its flexibility and friendliness. The interfaces were twelve in number but four were shown as samples in Figures 2 to 5. These interfaces are: interface where the users initiate and define a new project; two interfaces **A** and **B** as shown in Figures 3 and 4 as samples for the strategic decisions scores computations and figure 5 the results output interface.

This is an interface where the users initiate and define a new project. It involves entering project details such as : name, description, stakeholders, and other relevant information to get the project started.

"This panel will collect all information on STRATEGY A. The values expected are to be inputted using the dropdown boxes at the front of each attributes. Click on each dropdown box to choose between 'Excellent', 'Very Good', 'Good', 'Fair' and 'Poor'".

This same interface was used repeatedly from Strategic decision "A" to "K" but with different data.

The BLUE color indicates the strategic decisions for computation. Here is A (Combat operation center security).

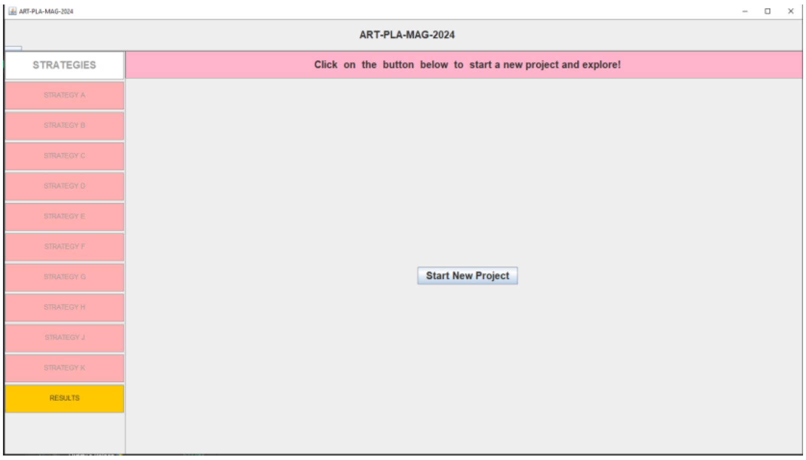

Figure 2. Project creation page of the model

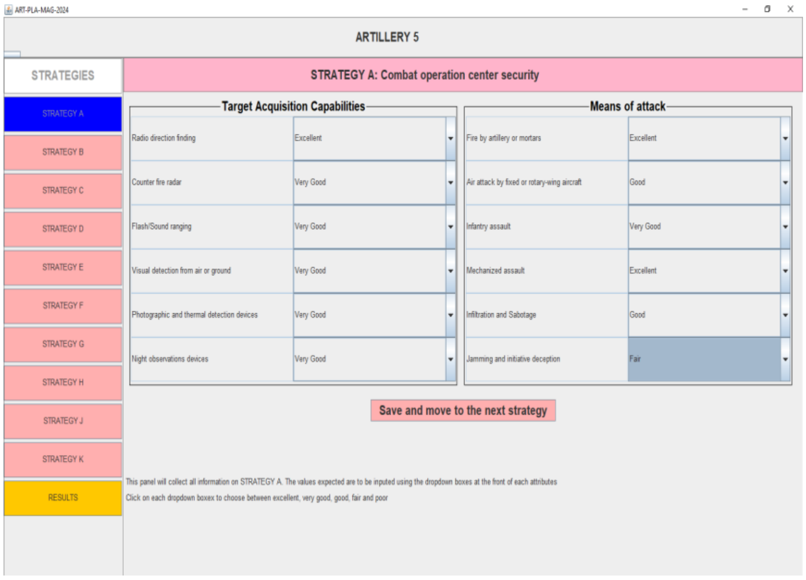

Figure 3. Strategy “A” interface

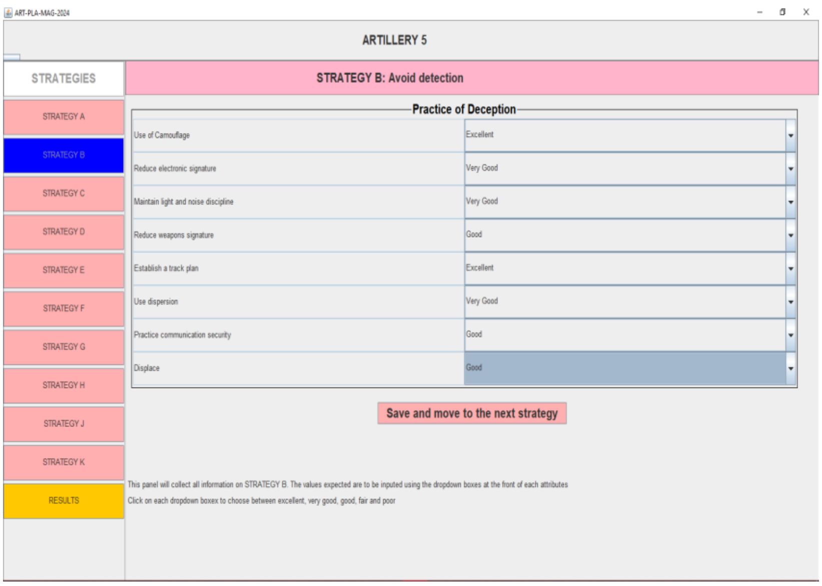

Figure 4. Strategy “B” interface

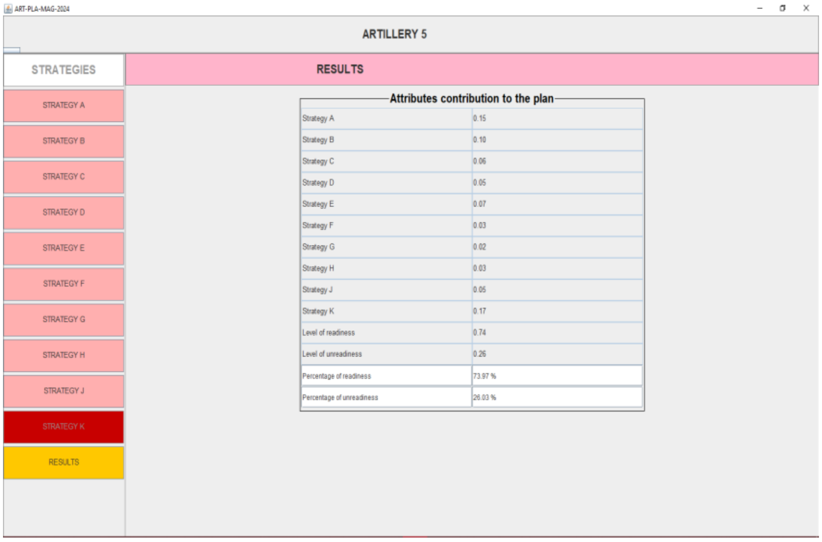

Figure 5. Results interface

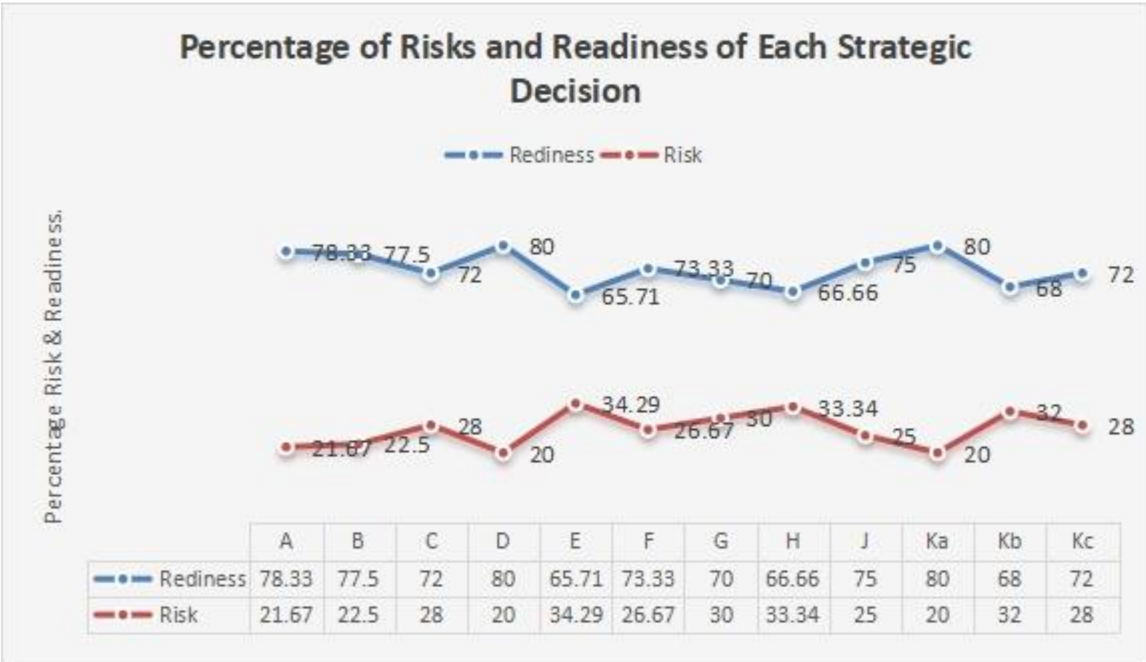

Figure 6. Graphical illustration of results generated for decision making

“This panel will collect all information on STRATEGY B. The values expected are to be inputted using the dropdown boxes at the front of each attribute. Click on each dropdown box to choose between ‘Excellent’, ‘Very Good’, ‘Good’, ‘Fair’ and ‘Poor’” The **BLUE** color indicates the strategic decisions for computation. Here is **“B” (Avoid Detection**). Other strategic decisions (“**C”** to” **K”$_c$**) were determined by inputting their relevant data.

Percentage Final Score (FS) = 233/315 = 0.73968
Total Score is 220 of 315. The percentage level of readiness for the mission. is [220/315] x 100 = **74.00%**. While the total mission risk taken is (100 – 74) % =**26 %.**
Therefore, the score is less than 248 but greater than 186. This score fell into scenario **C** of decision conditions (248 > **SDSp** ≥ 186) = **(Good).**

3. Results and Discussion

The developed algorithm and its application was found perfectly good for the purpose for which it was developed. The correlation r = 1 result ascertained this claim. Results generated were same as the manually computed results of Akinnuli *et al* [2]. Table 2 and figure 6 showed the performance of each strategic decision as it concerns readiness and unreadiness(risk).The strategic decision score/ point **(SDSp)** of this case study was 233 out of 315 Maximum points available. The score is Less than 248 but greater than 186 which fell into "**Scenario C "** of Decision Conditions (**248 > SDS_p ≥ 186**). The quantitative assessment is **(Good).** These results were 74% readiness and 26% unreadiness (risk), Concerning this war in question, risks involved was 26% to minimize this further and maximize the readiness percentage, the strategic decisions that contributed much to this 26% risk were to be improve upon based on their percentages of unreadiness in this order : **E** (Make Defensive Preparation, 34.23%,); **H** (Signals , 33.34%), **K_b** (32.00%,), **G** (Active and Passive Defense Measure,30%); **C** (Conduct Terrain Analysis using KOCOA, 28%), **Kc** (Logistical trains, 28%,); and **F** (Execute Defense Action, 26.67%) respectively. Time used for manual computation was one hour twenty minutes (1Hr. 20 Minutes) that is eighty minutes (80 minutes) while computer used fifteen (15) minutes, data input time and processing time added for this computations. The saving time for this prediction by ML is sixty five (65) minutes. This is a very good time. Part of this result is the pseudocode shown in appendix using Python programming language for its flexibility and friendliness.

4. Conclusions

Machine Learning (AI) model for artillery war strategic readiness prediction, and postmortem analysis for optimum performance has been developed tested and fund perfectly okay for use in this respect . This ML will find its usage in all military set up of Nations where artillery operations affects their war operations (which this research believed non) in under developed, developing and developed nations.

References

[1]. Achanta, R. Shaji, A. Smith, K. . Lucchi, A Fua, P. S. (2012) 'Süsstrunk' SLIC superpixels compared to state-of-the-art superpixel methods IEEE Trans. Pattern Anal. Mach. Intell., 34 (2012), pp. 2274-2282, 10.1109/TPAMI.2012.120 View at publisherView in Scopus Google Scholar

[2]. Akinnuli, B.O, Sukuntuni, A S; Olagunju R, and Asaolu O (2025), Unpublished Research Report, "Investigating Required Artillery Strategic Decision Making Criteria for War Readiness Prediction" Department of Industrial and Production Engineering, Federal University of Technology, Akure, Nigeria. pp (14-28).

[3]. Ali R, Furqan R, Bhargav M, Pradeep G, and Imran A,(2023) "Preventing crimes through gunshots recognition using novel feature engineering and meta-learning approach," IEEE Accessed, February, 2023.

[4]. Aung, T.S. (2021) Satellite analysis of the environmental impacts of armed-conflict in Rakhine, Myanmar Sci. Total Environ., 781 (2021), Article 146758, 10.1016/j.scitotenv.2021.146758 View PDF View article View in Scopus Google Scholar

[5]. Baumann, M. . Radeloff, V.C Avedian, V. Kuemmerle, T.(2015). Land-use change in the caucasus during and after the Nagorno-Karabakh conflict Reg. Environ. Change, 15 (2015), pp. 1703-1716, 10.1007/s10113-014-0728-3 View at publisher View in Scopus Google Scholar

[6]. Bennett, M.M. Van Den Hoek J. , Zhao, B. Prishchepov A.V. (2022 Improving satellite monitoring of armed conflicts Earth's Future, 10 (2022), Article e2022EF002904, 10.1029/2022EF002904 View at publisher

[7]. Brandt, M. Tucker, C.J. Kariryaa, A. Rasmussen, K. Abel, C. Small, J. (2020) An unexpectedly large count of trees in the West African Sahara and Sahel Nature, 587 (7832) (2020), pp. 78-82 View at publisherCrossrefView in ScopusGoogle Scholar

[8]. Case.S (2014). Putin's Undeclared War: Summer 2014 - Russian Artillery Strikes against Ukraine Bellingcat (2016) https://www.bellingcat.com/news/uk-and-europe/2016/12/21/russian-artillery-strikes-against-ukraine/, Accessed 10th October 2024 Google Scholar

[9]. Cheng, G. Han, J. (2016) A survey on object detection in optical remote sensing images

[10]. ISPRS J. Photogrammetry Remote Sens., 117 (2016), pp. 11-28, 10.1016/j.isprsjprs.2016.03.014 View PDF View article View in Scopus Google Scholar

[11]. Deininger, K. Ali, D.A. Kussul, N. Shelestov, A. Lemoine, G. Yailimova H. (2023) Quantifying war-induced crop losses in Ukraine in near real time to strengthen local and global food security Food Pol., 115 (2023), Article 102418, 10.1016/j.foodpol.2023.102418 View PDF View article View in Scopus Google Scholar.

[12]. Eun, J. Skakun S.(2022). Characterizing land use with night-time imagery: the war in Eastern Ukraine (2012–2016) Environ. Res. Lett., 17 (2022), Article 095006, 10.1088/1748-9326/ac8b23 View in Scopus Google Scholar.

[13]. Eva, K. Martin L., Matus P, Jozef J, and Anton C,(2015) "Gun type recognition from gunshot audio recordings," in 3rd international workshop on biometrics and forensics (IWBF 2015). IEEE, 2015, pp. 1–6.

[14]. Fann, C.M. (2006) Development of an Artillery Accuracy Model Naval Postgraduate School, Monterey CA, Dept. of Mechanical and Astronautical Engineering (2006) https://apps.dtic.mil/sti/citations/ADA462493 Google Scholar

[15]. Geza.G (2024).Potential Role of Artificial Intelligence in the Development of Field Artillery. Artificial Intelligence 6(1):9-21. DOI:10.35406/MI.2024.1.9, License CC BY-NC-ND 4.0.

[16]. Gorsevski, V. Kasischke, E. Dempewolf, J. Loboda, T. Grossmann, F.(2012) Analysis of the Impacts of armed conflict on the Eastern Afromontane forest region on the South Sudan—Uganda border using multitemporal Landsat imagery. Remote Sens. Environ., 118 (2012), pp. 10-20, 10.1016/j.rse.2011.10.023 View PDF View article View in Scopus Google Scholar

[17]. Iqbal H. S. (2021). Machine Learning: Algorithms, Real-World Applications and Research Directions Review Article, Published: 22 March 2021, Volume 2, article number 160.

[18]. John I, Jamelia A, Wagdy M, and Max D, (2023) "Gunshot detection from audio excerpts of urban sounds using transfer learning," in Proceedings of Meetings on Acoustics. AIP Publishing, 2023, vol. 51.

[19]. Long, Z and Qian L (2021). Study on Artillery Intelligent Engineering Concept and Overall Architecture Journal of Defense Management (2021) Volume 11, Issue 6

[20]. Lydia, K.D K, Andrew P H, Evelyn P.C, Peter P, Alex R, Patrick C .D, and Jake L S,(2022). "Automated detection of gunshots in tropical forests using convolutional neural networks," Ecological Indicators, vol. 141, pp. 109128, 2022.

[21]. Muhammad S. K, Junid M, Caleb R, Muhammad L U, Rahman S, and Furqan S,(2021). "Machine learning inspired efficient acoustic gunshot detection and localization system," University of Wah Journal of Computer Science, vol. 3, no. 1, 2021.

[22]. Muhammad Tahir Bhatti, Muhammad Gufran Khan, Masood Aslam, and Muhammad Junaid Fiaz, "Weapon detection in real-time cctv videos using deep learning," IEEE , vol. 9, pp. 34366–34382, 2021.

[23]. Rahul N, Sharik A, Ansari, S K, Fawaz Al, and Sayed M E, (2022) "Gun identification from gunshot audios for secure public places using transformer learning," Scientific reports, vol. 12, no. 1, pp. 13300, 2022.

[24]. Siddat M.D, Bin N. and Bradley M.W. (2022), "Audio event recognition in noisy environments using power spectral density and dimensionality reduction," in 2022 Intermountain Engineering, Technology and Computing (IETC). IEEE, 2022, pp. 1–5.

[25]. Simone R, Gabriele O, and Isra M. A, (2022) "Sound of guns: digital forensics of gun audio samples meets artificial intelligence," Multimedia Tools and Applications, vol. 81, pp. 30387–30412, 9 2022.

[26]. Zhicong C, Haoxin Z, Jingchang H, Lijun W, Shuying C, Qianwei Z, and Yang Y. (2023), "A wireless gunshot recognition system based on tri-axis accelerometer and lightweight deep learning," IEEE Internet of Things Journal, 2023.