



Article Automated Support for Battle Operational–Strategic Decision-Making

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Abstract: Battle casualties are the subject of study in military operations research, which applies mathematical models to quantify the probability of victory vs. loss. In particular, different approaches have been proposed to model the course of battles. However, none of them provide adequate decision-making support for high-level command. To overcome this situation, this paper presents an innovative high-level decision-making model, which uses an adaptive and predictive control architecture. The paper reports empirical evidence supporting our model by considering one of the greatest battles of World War II: the Battle of Crete.

Keywords: decision support systems; combat models; system dynamics; battle situation; warfare information system



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1. Introduction

Lanchester's seminal work [1] on battle dynamics' modeling has inspired significant research on the development of combat abstractions to support military decision-making under uncertainty, pursuing how to achieve superiority in combat. Lanchester's original model and its distinct evolving extensions have dominated the dynamic assessment of conventional land force balance for a long time [2], being used by major organizations (e.g., the US Army, the Office of the Secretary of Defense, etc.) to assess a wide variety of issues (e.g., evaluating the balance of operation theater [3,4], guiding decision on weaponry choices [5], etc.).

Nevertheless, it is worth noting that Lanchesterian models have important limitations, e.g., they perform an oversimplistic one-side treatment without taking into account the opponent's capabilities, and they cannot be used for disaggregated engagements.

Another matter to be taken into account is the abstraction level supported by the decision-making procedures. Military doctrine usually distinguishes the following three levels of command:

- 1. The strategic level studies the conflict from the most abstract perspective, considering the war final outcomes as a whole. It involves the overall planning, resource distribution, and organization of the military force. Additionally, it defines and supports the national policy.
- 2. War is divided into campaigns, which are organized into operations. The operational level deals with the design, arrangement, and execution of campaigns and principal operations.
- 3. The Tactical level implements the campaign operations on the battlefield.

Interestingly, most decision-making approaches, including the non-Lanchesterian ones, are focused on the tactical level of command [6,7]. In other words, the operational and strategic levels of command are insufficiently supported by existing decision-making systems.

This paper proposes an innovative framework that overcomes most limitations of Lanchesterian models and supports decision-making at the highest command levels: the

Journal Citation Reports	Browse journals	Browse categories	🙎 rherad	io@issi.uned.es 🗸
Home > Journal profile JCR YEAR 2020 •				
Mathematic	CS	Journal inform	nation	
		EDITION		
Open Access since 2013		Science Citatio Expanded (SCI	n Index E)	
ISSN		CATEGORY		
N/A		MATHEMATICS	- SCIE	
EISSN				
2227-7390		LANGUAGES	REGION	1ST ELECTRONIC JCR YEAR
		English	SWITZERLAND	2018
JCR ABBREVIATION		-		
MATHEMATICS-BASEL		Publisher info	rmation	
ISO ABBREVIATION		PUBLISHER	ADDRESS	PUBLICATION FREQUENCY
Mathematics		MDPI	ST ALBAN- ANLAGE 66, CH-4052 BASEL, SWITZERLAND	12 issues/year

Journal's performance

Journal Impact Factor

The Journal Impact Factor (JIF) is a journal-level metric calculated from data indexed in the Web of Science

Core Collection. It should be used with careful attention to the many factors that influence citation rates, such as the volume of publication and citations characteristics of the subject area and type of journal. The Journal Impact Factor can complement expert opinion and informed peer review. In the case of academic evaluation for tenure, it is inappropriate to use a journal-level metric as a proxy measure for individual researchers, institutions, or articles. Learn more



https://jcr.clarivate.com/jcr-jp/journal-profile?journal=MATHEMATICS-BASEL&year=2020&fromPage=%2Fjcr%2Fhome

3.000

2.250

1.500

0.75

0.00

View all years

	Differential Equations: A Survey and a		
	A Novel Bat Algorithm with Multiple Strategies Coupling for Numerical	44	~
	A Multi-Objective DV-Hop Localization Algorithm Based on NSGA-II in Internet of	36	~
100%	Dynamic Properties of Foreign Exchange Complex Network	33	~
50% = ;;;; 25% = 25% = 0%	Robust Synchronization of Fractional- Order Uncertain Chaotic Systems Based	32	~
2020	Long-Time Asymptotics of a Three- Component Coupled mKdV System	32	~
	Hybrid Control Scheme for Projective Lag Synchronization of Riemann-Liouville	32	~
	Hermite-Hadamard Type Inequalities for the Class of Convex Functions on Time	30	~
	Modeling of the Public Opinion Polarization Process with the	27	~
	Gradient-Based Iterative Parameter Estimation Algorithms for Dynamical	25	~

View in Web of Science

Journal Citation Indicator (JCI) 🕠

2.10

The Journal Citation Indicator (JCI) is the average Category Normalized Citation Impact (CNCI) of citable items (articles & reviews) published by a journal over a recent three year period. The average JCI in a category is 1. Journals with a JCI of 1.5 have 50% more citation impact than the average in that category. It may be used alongside other metrics to help you evaluate journals. <u>Learn more</u>

2018 JCR Years Journal Impact Factor • MATHEMATICS - SCIE

🛃 Export

Total Citations

🛃 Export

5,424

The total number of times that a journal has been cited by all journals included in the database in the JCR year. Citations to journals listed in JCR are compiled annually from the JCR years combined database, regardless of which JCR edition lists the journal.





View all years



https://jcr.clarivate.com/jcr.jp/journal-profile?journal=MATHEMATICS-BASEL&year=2020&fromPage=%2Fjcr%2Fhome

Citation distribution

The Citation Distribution shows the frequency with which items published in the year or two years prior were cited in the JCR data year (i.e., the component of the calculation of the JIF). The graph has similar functionality as the JIF Trend graph, including hover-over data descriptions for each data point, and an interactive legend where each data element's legend can be used as a toggle. You can view Articles, Reviews, or Non-Citable (other) items to the JIF numerator. Learn more



Open Access (OA)

The data included in this tile summarizes the items published in the journal in the JCR data year and in the previous two years. For example, in the 2020 JCR data, released in June 2021, the Open Access (OA) data show the publication model (Gold OA or subscription) of materials published in 2018, 2019 and 2020, and citations in 2020 to these items. This three-year set of published items is used to provide descriptive analysis of the content and community of the journal. Learn more

Items

TOTAL CITABLE % OF CITABLE OA

Citations*

total citable % of citable 0a 4,837 99.98% 🛃 Export

3,812 99.79%



GOLD OPEN Access 4,836 / 95.07%

SUBSCRIPTION

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OTHER

CITABLE

ITEMS)

27 /

0.70%

(NON

NON-CITABLE



^{*}Citations in 2020 to items published in [2018 - 2020]

Rank by Journal Impact Factor

Journals within a category are sorted in descending order by Journal Impact Factor (JIF) resulting in the Category Ranking below. A separate rank is shown for each category in which the journal is listed in JCR. Data for the most recent year is presented at the top of the list, with other years shown in reverse chronological order. <u>Learn more</u>

EDITION Science Citation Index Expanded (SCIE) CATEGORY MATHEMATICS 24/330

JCR YEAR	JIF RANK	JIF QUARTILE	JIF PERCENTILE	
2020	24/330	Q1	92.88	
2019	28/325	Q1	91.54	
2018	75/314	Q1	76.27	

Rank by Journal Citation Indicator (JCI)

Journals within a category are sorted in descending order by Journal Citation Indicator (JCI) resulting in the Category Ranking below. A separate rank is shown for each category in which the journal is listed in JCR. Data for the most recent year is presented at the top of the list, with other years shown in reverse chronological order. <u>Learn more</u>



CATEGORY MATHEMATICS 18/471

JCR YEAR	JCI JCI RANK QUARTILE	JCI PERCENTILE
2020	18/471 Q1	96.28
2019	24/470 Q1	95.00
2018	85/469 Q1	81.98
2017	105/462 Q1	77.38

Citation network

Cited Half-life

1.4 years

The Cited Half-Life is the median age of the citations received by a journal during the JCR year

TOTAL NUMBER OF CITES

5,424

NON SELF-CITATIONS

4,244

SELF-CITATIONS

1,180

Cited Half-life Data

Citing Half-life

8.6 years

The Citing Half-Life is the median age of the citations produced by a journal during the JCR year.

TOTAL NUMBER OF CITES

82,959

NON SELF-CITATIONS

81,779

SELF-CITATIONS

1,180

Citing Half-life Data

# OF CITED	CUMULATIVE	# OF CITES FROM	CITED
SOURCES	%	2020	YEAR
			All

5,424 citations 100.00% 858 sources >

years

2020	1,553 citations	28.63%	309 sources	>
2019	2,861 citations	81.38%	515 sources	>
2018	673 citations	93.79%	252 sources	>
2017	152 citations	96.59%	92 sources	>
2016	97 citations	98.38%	73 sources	>
2015	64 citations	99.56%	48 sources	>
2014	16 citations	99.85%	16 sources	>
2013	4 citations	99.92%	4 sources	>



2012	0 citations	99.92%	0 sources >
2011	0 citations	99.92%	0 sources >
Older	4 citations		

Content metrics

Source data

This tile shows the breakdown of document types published by the journal. Citable Items are Articles and Reviews. For the purposes of calculating JIF, a JCR year considers the publications of that journal in the two prior years. <u>Learn more</u>

2,247 total citable items

	ARTICLES	REVIEWS	COMBINED(C)	OTHER DOCUMENT TYPES(O)	0
NUMBER IN JCR YEAR 2020 (A)	2,205	42	2,247	11	10(
NUMBER OF REFERENCES (B)	80,167	2,645	82,812	147	10(
RATIO (B/A)	36.4	63.0	36.9	13.4	

Average JIF Percentile

🛃 Export

The Average Journal Impact Factor Percentile takes the sum of the JIF Percentile rank for each category under consideration, then calculates the average of those values. <u>Learn more</u>

all categories average 92.88	EDITION Science Citation Index Expanded
	MATHEMATICS

Contributions by

Contributions by

organizations

Organizations that have contributed the most papers to the journal in the most recent three-year period. <u>Learn more</u>

UNIVERSITY

- 10 CANKAYA 47 UNIVERSITY
- 11 PRINCE SULTAN 45 UNIVERSITY
- 12 CENTRE 41 5 NATIONAL DE LA RECHERCHE SCIENTIFIQUE

https://jcr.clarivate.com/jcr.jp/journal-profile?journal=MATHEMATICS-BASEL & year=2020 & from Page=%2 Fjcr%2 Fhome and the set of the set of

country/region

Countries or Regions that have contributed the most papers to the journal in the most recent three-year period. <u>Learn more</u>

- 2 Spain 469
- 3 Saudi Arabia 400
- 4 South Korea 363 5 USA 310 6 Taiwan 302



JULINI	יעט
(CNRS)	

Journal Citation Reports - Journal Profile

	(CNRS)		7	Pakistan	233
13	KING MONGKUTS UNIVERSITY OF	40	8	Russia	220
	THONBURI		9	India	207
-	UNIVERSITY OF GRANADA	40	10	Romania	198
15	GYEONGSANG	39	11	Turkey	188

Additional metrics

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Eigenfactor Score 0.00646

The Eigenfactor Score is a reflection of the density of the network of citations around the journal using 5 years of cited content as cited by the Current Year. It considers both the number of citations and the source of those citations, so that highly cited sources will influence the network more than less cited sources. The Eigenfactor calculation does not include journal self-citations.

Learn more 0.00546 0.00546 0.00546 0.00161 0.00000 2016 2017 2018 2019 2020 FP Years

Normalized Eigenfactor **1.35598**

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The Normalized Eigenfactor Score is the Eigenfactor score normalized, by rescaling the total number of journals in the JCR each year, so that the average journal has a score of 1. Journals can then be compared and influence measured by their score relative to 1. Learn more

Article influence score 0.354

The Article Influence Score normalizes the Eigenfactor Score according to the cumulative size of the cited journal across the prior five years. The mean Article Influence Score for each article is 1.00. A score greater than 1.00 indicates that each article in the journal has above-average influence. Learn more





5 Year Impact Factor

2.165

View Calculation

The 5-year Impact Factor is the average number of times articles from the journal published in the

Immediacy 🛃 Index

0.691

View Calculation

The Immediacy Index is the count of citations in the current year to the journal that reference content in this same



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past five years have been cited in the JCR year. It is calculated by dividing the number of citations in the JCR year by the total number of articles published in the five previous years. year. Journals that have a consistently high Immediacy Index attract citations rapidly. <u>Learn more</u>





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