

Dead Reckoning Applied to Online Videogames: A Systematic Review

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Abstract—This systematic review analyses studies on Dead Reckoning algorithms for multiplayer video games, focusing on enhancing user experience and network efficiency. Findings indicate that integrating physical and adaptive models into Dead Reckoning significantly improves prediction accuracy and efficiency. Key studies demonstrate the benefits of these enhancements in reducing latency and bandwidth consumption. Despite substantial advancements, there is a notable gap in the application of machine learning techniques within Dead Reckoning algorithms. Most existing research relies on traditional methods, with limited exploration of how machine learning can further optimise prediction accuracy and network performance. Future work should explore new algorithms and their application across various game types to further enhance gameplay quality. Additionally, there is a need for interdisciplinary research combining insights from computer science, network engineering, and game design to develop more robust and versatile Dead Reckoning solutions.

Index Terms—Dead Reckoning, Multiplayer Video Games, User Experience, Network Efficiency, Prediction Models, Latency Reduction, Bandwidth Consumption, Hybrid Approaches, Machine Learning, Gameplay Quality.

I. INTRODUCTION

In recent decades, the use of the internet as a general medium oriented towards leisure has become increasingly popular. Video games have emerged as one of the primary forms of entertainment, reaching not only a young audience but also a broader demographic through more ambitious perspectives. Due to the extensive use of data networks over the past decades, the infrastructures supporting this network have transformed and improved over the years, enhancing both the quality and the volume of data they can transmit. This evolution has necessitated research into methods for increasing resource efficiency to prevent data network saturation. Video games are a currently trending medium, with real-time multiplayer games being one of the most popular forms of entertainment today.

However, the fact that a large number of users connect to an online server to play poses a challenge to data transmission rates. Human behaviour can be unpredictable, requiring servers to frequently check the actions performed by users, which often leads to high bandwidth consumption and resource usage.

Among the various video game genres, racing games stand out. In these games, player positioning is a crucial element, as it determines important aspects such as the players' locations on the track while moving at high speeds, their final positions at the end of the race, and interactions between cars. To mitigate the effects of the challenges posed by real-time

gameplay, several techniques have been developed, one of which is the focus of this systematic review: Dead Reckoning. This technique primarily aims to anticipate player movements based on previously received patterns, thus reducing the need for constant transmission of player position data.

Within these types of techniques, there is a specialisation related to racing video games, as these games feature a predefined track layout that serves as a subject for studying the possible positions a player might occupy at a given moment. This specialisation simplifies the application of Dead Reckoning techniques, as the number of positions to estimate is reduced compared to other types of virtual environments.

II. METHODOLOGY

The methodology employed for this systematic review followed the Biocini protocol. The primary objective of this review was to identify studies related to the definition and/or application of Dead Reckoning strategies aimed at improving user experience in the context of video games and/or multiplayer applications.

The problem under study involves understanding the types of Dead Reckoning, their implementation techniques, and their applications, with the goal of proposing the most suitable type for a video game environment.

In this review, studies were sought that could answer at least one of the following questions:

- How are Dead Reckoning algorithms implemented to enhance user experience?
- In what ways do different implementations of Dead Reckoning improve user experience?

To carry out the search for relevant studies, a series of search strings were developed and used to locate published works in ScienceDirect, IEEE Xplore, and the Association for Computing Machinery (ACM). These are prestigious platforms that publish well-regarded articles. It is worth noting that grey literature recommended by academics from the Faculty of Business Sciences at the University of Bío-Bío was also considered.

As for the languages of the search, only works found in English and Spanish were considered. The search strings were executed in both languages as well.

A. Definition of Search Strings

To define the search strings to be used, a series of keywords with their corresponding synonyms in both English and Spanish were first gathered.

Keyword	English Synonym	Spanish Synonym
User	Customers, user, users	Cliente, usuario, usuarios
Dead Reckoning	Dead Reckoning	Navegación a estima
Multiplayer	Multiplayer	Multijugador
Multiplayer Online Game	MPOG	Juego multijugador en línea

TABLE I
KEYWORDS AND SYNONYMS

Once this foundation was established, these words were used to create the following search strings:

Search Strings in English
"dead reckoning applications"
"position prediction in multiplayer"
"multiplayer position prediction" AND "cars"
"dead reckoning" AND "racing games"
"dead reckoning applied" AND "videogames" OR "racing"
"enhanced jitter concealing" AND "videogames" OR "multiplayer"

TABLE II
SEARCH STRINGS IN ENGLISH

Search Strings in Spanish
"aplicaciones de dead reckoning"
"predicción de posicionamiento multijugador"
"predicción de posicionamiento multijugador" AND "autos"
"dead reckoning" AND "juegos de carreras"
"dead reckoning aplicado" AND "videojuegos" OR "carreras"
"reducción de jitter mejorada" AND "videojuegos" OR "multijugador"

TABLE III
SEARCH STRINGS IN SPANISH

B. Selection of Studies

To select studies relevant to the topic at hand, the following inclusion and exclusion criteria were established.

1) Inclusion Criteria:

- Studies related to the implementation of Dead Reckoning for enhancing user experience.
- Studies related to the improvement and/or optimisation of Dead Reckoning algorithms.

2) Exclusion Criteria:

- Studies that are unrelated to the impact of Dead Reckoning on user experience.
- Studies that do not contribute to the implementation and/or improvement of Dead Reckoning algorithms.

3) *Preselection Procedure:* The procedure used for the preselection of studies involved utilising the search strings in the selected sources. Once identified, the title, abstract, keywords, future work, and bibliography of each study were examined to ensure relevance to the topic. Both inclusion and exclusion criteria were then applied to determine whether the study should be preselected.

C. Application of Inclusion Criteria

As previously mentioned, it is sufficient for the article to be related to Dead Reckoning in the context of enhancing user experience, or to address the improvement and optimisation of Dead Reckoning algorithms.

D. Application of Exclusion Criteria

For the exclusion criteria, it is sufficient for at least one of the defined conditions to be met.

E. Study Registration

For the registration of studies, a table was used, as shown below. This table details the authors, title of the article, a brief summary, the publication date, and whether or not the study is relevant to the research.

Study Registry				
ID	Author	Name	Summary	Relevant
-	-	-	-	-

TABLE IV
STUDY REGISTRY FORMAT

III. RESULTS

The application of the protocol initially involves conducting searches using each of the search strings defined during the development of the methodology.

When performing the searches across each of the portals, which were conducted in May 2024, the following number of results were obtained:

- "dead reckoning applications" (134 results).
- "dead reckoning" AND "racing games" (14 results).
- "position prediction in multiplayer" (3 results).
- "multiplayer position prediction AND cars" (1 result).

In total, 152 publications were found, of which 18 were preselected, resulting in 7 studies being definitively selected.

It is important to highlight that, although initially both English and Spanish search strings were considered, the latter yielded no results in the search engines used. Therefore, the final body of studies consists exclusively of works written in English.

In addition to the above consideration, the last two search strings defined initially were also eliminated, as they produced overly general results, which mostly were not related to the topic of this review.

A. Analysis of Results

For the analysis of results, the open-source tool Bibliometrix was used with the help of Biblioshiny, in the R programming language.

Since the results were obtained from platforms where scientific articles are regularly published, they were exported directly as ".bib" files, which were then loaded into Biblioshiny.

The graphs shown in figs. 1 to 3 were exported directly from Biblioshiny. They clearly display the most prominent authors

among the selected studies related to Dead Reckoning, as well as the most relevant sources and keywords within these studies.

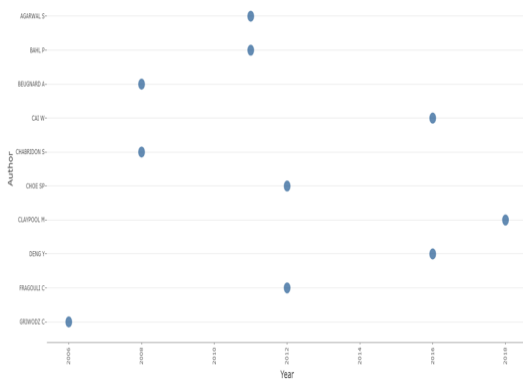


Fig. 1. Most Highlighted Authors



Fig. 2. Most Relevant Sources

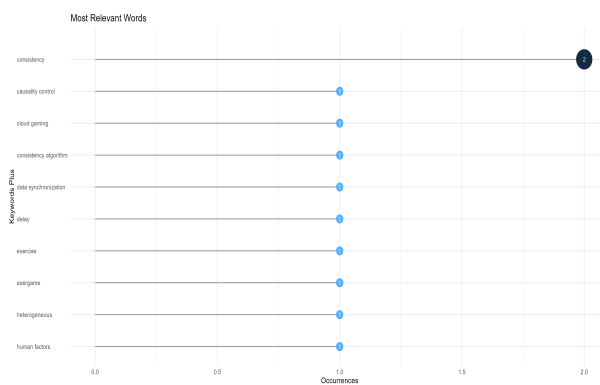


Fig. 3. Most Relevant Words

It should be noted that, due to the strict format requirements of Biblioshiny, not all search results exported from the various portals could be visualised with the tool. Only results obtained from the ACM platform were considered, as they met the required format.

According to the information obtained, a significant portion of the studies related to the topic are relatively recent, ranging

from Evaluating Dead Reckoning Variations with a Multi-Player Game Simulator [1] from 2006, up to Game Input with Delay—Moving Target Selection with a Game Controller Thumbstick [2] from 2018. In addition, although not reflected in the graphs, there are even more recent studies published in the other two portals used, such as Predictive Dead Reckoning for Online Peer-to-Peer Games [3], published in 2023.

IV. SELECTED STUDIES

The studies selected in this systematic review are divided into two groups. The first group consists of 18 publications that were chosen based on the criteria defined in section II-B3. These studies were recorded in the table described in section II-E. From this initial analysis, 7 studies out of the 18 were selected to constitute the final works.

A. Preselected Studies

Within the group of preselected works, a broad spectrum was identified in terms of what can be addressed through the application of Dead Reckoning and the techniques that have been attempted to improve the user experience in video games and multiplayer applications. For example, there are certain studies discussing Dead Reckoning to mask latency in multiplayer games, such as An Adaptive Scheme for Consistency among Players in Networked Racing Games [4], Improving end-to-end quality-of-service in online multi-player wireless gaming networks [5], and Consistent Synchronization of Action Order with Least Noticeable Delays in Fast-Paced Multiplayer Online Games [6]. Moreover, there are even studies discussing Dead Reckoning applied specifically to racing video games, such as Influences of Network Latency and Packet Loss on Consistency in Networked Racing Games [7] and An Adaptive Scheme for Consistency among Players in Networked Racing Games [8].

There were also studies applying Dead Reckoning directly in multiplayer video game simulations for predictions, such as Evaluating Dead Reckoning Variations with a Multi-Player Game Simulator [1] and A Network-Centric Approach to Enhancing the Interactivity of Large-Scale Distributed Virtual Environments [9].

Finally, studies were identified that, while discussing Dead Reckoning conceptually, were not selected because they deviated too much from the scope of multiplayer video games. These include Towards a Position and Orientation Independent Approach for Pervasive Observation of User Direction with Mobile Phones [10], which discusses a form of Dead Reckoning to predict a person's movement direction based on mobile device accelerometers and magnetometers, and The Need for Speed: Testing Acceleration for Estimating Animal Travel Rates in Terrestrial Dead-Reckoning Systems [11], which covers Dead Reckoning applied to estimating terrestrial animal migration.

B. Selected Studies

Among the studies selected for more in-depth analysis, those that fit perfectly within the focus of this systematic review and fully meet the inclusion criteria of this work are included.

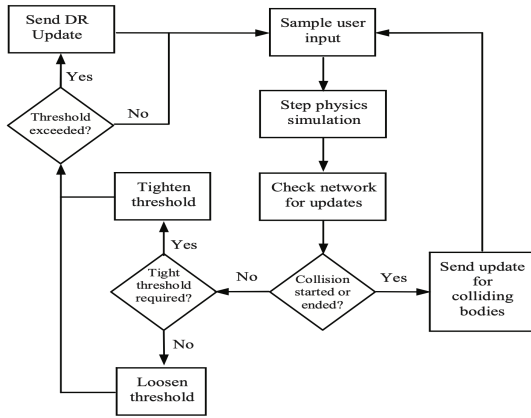


Fig. 4. Flowchart of state management techniques proposed for multiplayer games with physical awareness.

First, we have two studies that discuss improving Dead Reckoning models through the incorporation of concepts that can enhance player behaviour prediction. For example, in An Enhanced Dead Reckoning Model for Physics-Aware Multiplayer Computer Games [12], the active incorporation of game physics into Dead Reckoning is mentioned to achieve better predictions, as shown in fig. 4. Similarly, Adaptive Δ -Causality Control with Adaptive Dead-Reckoning in Networked Games [8] discusses adaptive control applied to Dead Reckoning, specifically related to multiplayer games.

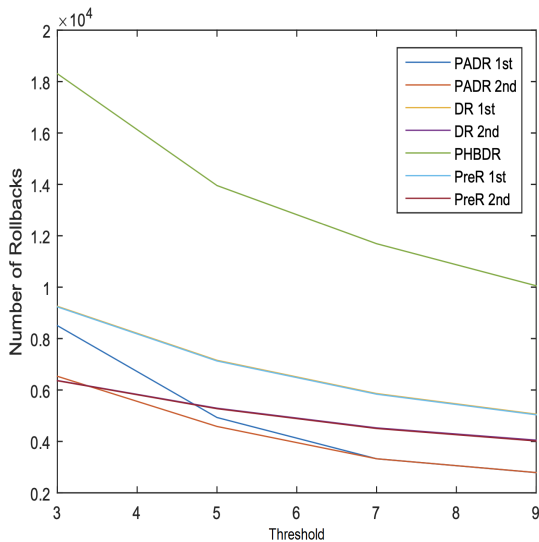


Fig. 5. Prediction Accuracy

Secondly, there are studies that analyse the usability of certain Dead Reckoning schemes for online games, such as On the suitability of dead reckoning schemes for games [13]. Additionally, some studies compare different algorithms; Comparing dead reckoning algorithms for distributed car simulations [14] examines and compares different types of Dead Reckoning implementations, highlighting key metrics such as

computational cost, bandwidth cost, and, most importantly, the prediction accuracy they can generate, as shown in fig. 5.

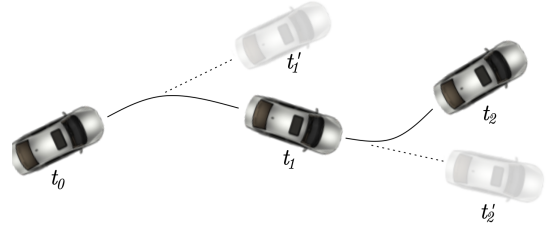


Fig. 6. Extrapolating the position of an opponent from periodic updates.

One of the studies most relevant to this systematic review is Predictive Dead Reckoning for Online Peer-to-Peer Games [3]. It details Dead Reckoning applied in modern racing video games, from theoretical application to practical experiments and implementation in a racing simulator. Additionally, this paper references the Peer-to-Peer (P2P) protocol, which requires special considerations when predicting object movement (fig. 6). The future work section of this study specifically mentions the need for further testing and consideration of collisions between objects.

V. CONCLUSION

This work presents a thorough analysis of Dead Reckoning algorithms used in multiplayer video games. It has been demonstrated that integrating physical and adaptive models into these algorithms significantly improves prediction accuracy and network efficiency. These advancements not only reduce latency but also optimise bandwidth usage, which is crucial for a smooth gaming experience.

Despite these advancements, a lack of research in applying machine learning techniques to Dead Reckoning algorithms has been identified. Most current studies rely on traditional methods, and there is untapped potential for machine learning to further enhance prediction accuracy and network performance. Although this is a relatively underexplored topic, there is both interest and material available to advance in this area, which is undoubtedly a latent field of study.

Furthermore, given the limited number of studies in Spanish, we can conclude that this is a less popular topic within this linguistic community. Future work should focus on exploring new algorithms and their application in various types of games. Additionally, fostering interdisciplinary research that combines knowledge from computer science, network engineering, and game design is essential to develop more robust and versatile Dead Reckoning solutions.

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