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ARTICLE

Modeling Sentence Meaning Using Linear Operators in a Vector Space Semantics Framework: An Interdisciplinary Approach

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ABSTRACT

This paper presents a simplified yet interdisciplinary framework for modeling sentence meaning by integrating foundational concepts from linguistic semantics and operator theory. The core idea is to represent content words, particularly nouns, as vectors in a high-dimensional semantic space, while function words such as adjectives and verbs are modeled as linear operators that act upon or combine these vectors. This approach allows for a structured and computationally tractable method of capturing compositional meaning in natural language. Using basic mathematical operations such as matrix multiplication and the tensor product, the paper demonstrates how meanings of phrases and sentences can be derived through illustrative examples like *angry dog* and *dogs chase cats*. These examples showcase how complex expressions are formed by systematically applying operators to simpler vector representations. By bridging the gap between formal linguistic theory and linear algebra, the proposed model offers an intuitive and rigorous framework for understanding how meaning emerges from the combination of words in context. Furthermore, this operator-theoretic perspective opens new avenues for the development of interpretable, modular, and potentially more sustainable natural language processing systems. The framework not only contributes to theoretical investigations in semantics but also holds promise for real-world applications in artificial intelligence, particularly in building transparent and explainable models for language understanding.

Keywords: Artificial Intelligence, Vector Space; Linear Operator; Compositional Semantics; Computational Linguistics; Mathematical Modeling; Interdisciplinary Approach

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1. Introduction

How language conveys meaning is a fundamental question that crosses the boundaries of linguistics, philosophy, and cognitive science. Human beings can communicate abstract thoughts, intentions and emotions using language; an important intellectual problem has been to identify how the structure of language contributes to the construction of meaning. A number of compelling approaches to this problem has been using mathematical formalisms as a model of semantic composition, the creation of more complex meanings from smaller linguistic units.

Natural language models of meaning can be designed to be structured and interpretable by making use of tools from linear algebra, more specifically operator theory. Precisely, functional elements like adjectives, verbs and determiners are represented and allow their compositional interaction, in which these elements do not merely carry content, but also significantly transform or modify the meanings of other lexical items. Based on a framework whereby these functional components are considered linear operators operating on noun vectors, and therefore are dynamic in nature, whereby they simultaneously help to align and integrate components of word meaning as part of coherent phrases and sentences. Such treatment makes possible a systematic and computationally viable theory of semantics that is based on mathematics.

The Principle of Compositionality is foundational concept underpinning this work. It is traditionally attributed to the logician Gottlob Frege. According to this principle, the meaning of an arbitrary complex linguistic expression is determined on the basis of the meanings of its components and syntactic rules of their coordination. It is a theoretical base from which to understand the construction of meaning in a rule governed and predictable manner. In this paradigm, the problem is to construct models of compositional syntax that not only follow the principles of compositionality but also provide an account of fine-grained semantic distinctions in a compositional, interpretable and scalable fashion.

Higginbotham (1985), however, revisits and extends Frege's ideas about compositional semantics within a generative linguistic framework [1]. In his seminal 1985 paper, *"On Semantics,"* Higginbotham integrates Fregean compositionality with contemporary syntactic theory, specifically, the Government and Binding framework, to show how semantic interpretation can be systematically aligned with syntactic structure. By doing so, Higginbotham not only reaffirms Frege's insight that structure governs meaning, but also operationalizes it within a model of natural language that accounts for argument structure, thematic roles, and variable binding. This allows for a more linguistically realistic model of compositional semantics, where meanings are not only logically constructed but also constrained by grammatical relations. Higginbotham's work thus serves as a bridge between the abstract, logic-driven traditions of Fregean semantics and the empirically grounded, structure-sensitive analysis required in linguistic theory.

In recent years, it was proposed in distributional semantics and computational linguistics to use powerful models of analysis of word co-occurrence in large text corpora. In such models of representation, word meanings are modeled as vectors that live in high dimensional spaces, and the claim is that semantic similarity can somehow be inferred from patterns of usage. Vector space models in natural language processing are remarkably successful in practice, and can thus be taken as an empirical basis for lexical semantics. However, compositionality is difficult for these models, especially with respect to complex constructions and logical relationships.

However, this limitation prevents researchers from applying operator theoretic approaches that extend vector space models by taking a function, often a matrix shape, over the word vectors. Adjectives are conceived as linear transformations that, applied to a noun vector, yield a new vector which expresses the altered meaning of the adjective, and transitive, or monotransitive, verbs are modeled as binary operators on subject and object noun phrase vectors. They present a mathematical structure for meanings that fine grain structuring of meanings, and is compatible with both linguistic theory and implementation as a computer program.

In this paper, this existing body of work is extended by presenting a model that simplifies the theoretical grounding of this line of work to present a model for the study of sentence-level meaning that applies linear algebraic methods. Two goals are the goals of this study. The first part tries to show that treating functional linguistic elements as linear operators gives a straightforward and natural way to account for how meaning composition takes place in natural language. Second, it aims to demonstrate that the mathematical form of such operator-based models is rigorous, while the modeling terminology is appropriate for pedagogical and computational applications. This work is an attempt to unite the symbolic and the statistical approaches to language understanding, by integrating insights into learning word meanings from formal semantics of a certain kind, vector space modeling, and operator theory.

Using a toy model and illustrative examples, the study makes these ideas accessible to a wide audience, linguists, computer scientists, educators, etc. The model is made intentionally simplified for clarity, yet the presented principles lay a basis which may be thereof used for extension to more complex and realistic systems in future research. The overall endeavor of the paper is to demonstrate the power of math abstraction to model the many and subtle phenomenon of human language.

2. Literature Review

2.1. Operator Theory in Compositional Semantics: A Foundation for Sustainable Language Technologies

Complexity and the lack of simple one–dimensional solutions to sustainability challenges require new and innovative, interdisciplinary solutions, which are the embodiment of advanced mathematical modelling and sophisticated language processing. The convergence of the context and of operator theory with the compositional semantics offers a new lens for advancing the linguistic theory and Natural Language Processing (NLP) and for building intelligent systems that assist achieving the sustainability objectives. Accordingly, this literature review examines how operator theory has been utilized in linguistic semantics, and in its developing idea of associating operator theory with developing computable systems which strive to be sustainable, adaptive, and ethically aligned.

2.2. Operator Theory in Compositional Semantics

Compositional semantics, one of the central areas of theoretical linguistics, intends to explain how meanings of complex expressions arise from the meanings of their parts and the rules used to combine them. Traditional rule-based or symbolic approaches have made foundational contributions but often fall short in representing context-dependent meaning, especially in sustainability discourse, where language is charged with ethical, ecological, and policy implications.

Research has turned recently to distributional models of meaning, which represent words as vectors in high-dimensional semantic spaces. Linear transformations (operator theory) have been of great use in extending these models so as to handle compositionality more effectively. Kartsaklis (2014) reviews how distributional semantics can be combined with formal semantic models through linear operators, and uses models that are more robust and grounded in actual use of language in the real world [2]. These methods allow for capturing relational meaning, polysemy, and syntactic dependencies, features critical for understanding complex sustainability narratives in texts about law, environment, and policy.

Building on this integration, Basile, Caputo, and Semeraro (2012) further develop such integration by proposing techniques for syntactic structures incorporation in distributional semantic spaces by means of operator-based transformations [3]. They demonstrate that syntactic roles substantially impact sentence level meaning construction and including this is better for accuracy and richness of semantic interpretation in vector-based models. These improvements are necessary for sustainability-related NLP applications including policy modeling, climate risk communication, and environmental knowledge extraction where subtle shifts in syntactic framing can impact the understanding of scientific or regulatory texts.

2.3. Mathematical Foundations and Sustainable System Modeling

Operator theory itself has its roots from the realm of functional analysis and its aim is to study linear operators on function spaces. Its mathematical rigor and flexibility have made it central to a great many of applied fields, including quantum mechanics, differential equations, signal processing, and increasingly, complex system modeling.

The contemporary developments in Operator Theory: Advances and Applications (of which, the Special Issue will be a part in 2024), particularly with regards to spectral analysis on networks and operator methods to solve nonlinear equations, are ever more applied to modelling for sustainability [4]. As such, these mathematical tools are particularly suitable for the evaluation of and optimization over large scale systems, for example energy networks, water distribution, ecological system, all of which can share, to a large extent, similar structural complexities as the linguistic hierarchies.

It can be said that operator theory is a valuable designing tool for sustainable systems because it can model interaction, stability, and transformation dynamics. In the case of green urban planning or system resource allocation, for example, operators are used to simulate how the behavior of a system and the optimization of certain outcome will be affected under constraints, these are the same way compositional operators have been used to model the interaction between linguistic elements as they construct meaning.

2.4. Towards Sustainable Language Technologies

The crossing over of linguistics and operator theory raises the prospect of not only theoretical progress but also an enhancement over all in the treatment of on a daily basis issue. With computational systems becoming more integrated into our decision-making environments (e.g., climate governance, environmental monitoring, and for environmental or sustainable development), there is increasing demand for intelligently informed (intentionally so) and ethical language technologies. It is clear from the work of Das, Saikia, and Bora (2024) in taking the mathematical modeling point of view to investigate use in advancing Industry 5.0 – a vision of industry that emphasizes human centric, resilient, and sustainable production [5]. The research reveals how intelligent systems and operator-based optimization can lead to more sustainable industrial practices. This integrates with compositional semantic modelling, allowing for interfaces that can be cognitively processed by humans and meaningfully process and respond to sustainability goals, to be possible including in the creation of eco aware decision support and interpretable AI tools.

The Special Issue on Sustainability of Theories in Mathematical Finance and Economics (2020) proves how sustainable financial instrumentation could be analogous to sustainable financial modeling [5]. In this case linguistic dimension is becoming increasingly relevant, as the algorithms are looking through financial and policy texts to extract and assess trends, to generate insights. The complex semantics of such documents is navigated by operator enhanced compositional models for these systems, that ensure that the sustainability metrics and ethical considerations are properly interpreted and applied.

2.5. Contribution and Novelty of the Present Study

With respect to system modeling, previous work has used operator theory to achieve compositional semantics and sustainable system modeling in engineering and economics, which have taken place independently [2,3,5]. The existing literature does not offer a unified approach to semantic modeling based on operators which are specifically linked to sustainability. In addition, sustainability has largely been considered as an application area, an 'add on to current existent models rather than considered from the ground up as part of the linguistic and mathematical architecture.

The novelty that this study offers is a reconceptualization of compositional semantics from a sustainability standpoint. It proposes a framework in which operator theory is in a position not just to help semantic modeling, but to enable creation of sustainable, interpretable, and adaptive language technologies. By situating sustainability within both theoretical and applied development, this research advances a new interdisciplinary agenda, one that aligns linguistic theory, mathematical modeling, and environmental responsibility. It results therefore in a framework that tackles both language's structural complexity and the systemic complexity of sustainability problems synergistically.

3. Background

3.1. Operator Theory in Mathematics

Operator theory is part of mathematics in which one studies about transformations, especially linear transformations acting on vector spaces. These transformations are typically expressed using matrices, allowing for precise, rule-governed manipulations of vectors. Such operations lie at the core of many applied disciplines, including mathematics, physics, computer science, and engineering [6–9].

Formally, an operator T is a mapping from one vector space V to another space W, written as: $T\colon V \rightarrow W$

When both V and W are finite-dimensional and T is a linear operator, it can be represented by a matrix A, such that for any vector $v \in V$,

$$\mathrm{T}(v)=\mathrm{A}v \tag{1}$$

This matrix representation allows for concrete and efficient computation of how one object (a vector) is transformed into another under a set of rules encoded in the matrix. Importantly, operators can also be composed, meaning that multiple transformations can be applied in sequence. Since the order of composition affects the result (i.e., AB≠BAAB), this echoes with word order sensitivity in natural language.

Beyond finite-dimensional cases, operator theory also explores transformations on infinite-dimensional function spaces and their spectral properties [10]. While this paper focuses on simpler linear algebraic formulations, the broader framework offers rich modeling potential for complex systems like natural language.

3.2. Vector Space Models in Semantics

In linguistic semantics, particularly distributional semantics, the meanings of words are inferred from the contexts in which they appear. This idea is rooted in the distributional hypothesis [11], which proposes that words used in similar contexts tend to have similar meanings. Accordingly, words are represented as vectors in high-dimensional semantic spaces derived from co-occurrence statistics in large corpora [12]. For example, the words "cat" and "dog" often share similar distributional patterns, leading to similar vector representations.

However, while these vector space models excel at representing individual word meanings, they struggle with semantic composition—how to combine word vectors into phrase or sentence-level meanings. A range of approaches has been proposed:

- **Additive and multiplicative models** [13]: These involve combining word vectors through summation or element-wise multiplication. Though computationally simple, these models often fail to account for syntax and word order.
- **Tensor-based models** [14]: These use higher-order tensors to encode grammatical relations and word interactions. While more expressive, they are computationally demanding.
- **Matrix-based models** [15]: In these models, some words—such as adjectives and verbs—are represented as **matrices** that act on the vectors of other words. For instance, an adjective like "red" can be represented as a matrix that transforms a noun vector (e.g., "car") into the meaning of "red car".

The matrix-based approach is adopted in this paper since it can represent functional behavior more intuitive in language, and it is computationally simple compared to tensor-based approaches that constitute a direct extension of the matrix-based approach.

3.3. From Math to Meaning

This study bridges these two domains, i.e., operator theory and linguistic semantics, and presents a framework for systematic modeling of how sentence meaning arises from the meanings of the individual words in terms of some mathematical grounds based on operator theory. With basic linear algebra—vectors and matrices—it tries to simulate (some aspects of) the semantic composition process and hopes to do so in a way that is both intuition and rigorous.

This approach represents content words like nouns as vectors, while function words like verbs and adjectives are treated as linear operators, matrices, that act on those vectors to produce new semantic structures. Similarly, the numbers in matrices operate on a vector in mathematics and functional expressions in language modify or combine more primitive concepts [14,15].

The purpose of this framework is not to propose a new theory of meaning from scratch, but to reveal that even elementary operator-theoretic tools can provide deep insights into language structure. The approach is accessible, extensible, and connects formal semantics with computational models, presenting a promising direction for both theoretical and applied research in linguistic meaning.

4. Methodology

In this section we discuss how natural language expressions can metaphorically be expressed in terms of linear algebraic and operator theoretic principles. First, words are represented as vectors, function words as linear transformations, and their representations compose meaningful phrases and sentences.

4.1. Word Representation

In this framework, a vector representation for each noun is given as a vector in a high dimensional semantic space. The vectors capture contextual meaning of words in real linguistic data, or in the case of a toy model, from predefined simplification. It constructs the space of high dimension where the words closer to each other are semantically similar and the distance between two dissimilar words is greater. Distributional techniques are generally used to learn the vectors from large corpora, and in simplified models for clarity and control [12], the vectors are assigned manually. For example, in an actual model, similar reference to two words such as 'dog' and 'cat' would have vectors that are also close to each other, implying that they are of the same type of animal. These vectors are manually assigned to these vectors in a toy model, such as by size, shape, or behavior.

This vector-based representation is fundamental because it allows for computational manipulation of words and supports operations like addition, subtraction, and multiplication, which facilitate the modeling of word meanings in context.

4.2. Adjectives and Verbs as Operators

Adjectives and verbs are modeled as matrices or linear operators that act on noun vectors to modify or combine their meanings. The idea here is that adjectives and verbs do not independently carry their own meaning in the same way nouns do. Instead, they interact with noun vectors to produce new meanings [14].

- **Adjectives**: An adjective like “angry” modifies the meaning of a noun (e.g., “dog”) by performing a **matrix multiplication** with the noun vector. The matrix representing the adjective defines how the noun vector is transformed.

Example:

$$\text{angry dog} = A\times\text{vec(dog)} \tag{2}$$

Here, A is the matrix representation of the adjective "angry", and vec(dog) is the vector representing the noun "dog". The result of this matrix-vector multiplication produces a new vector that encodes the meaning of the expression “angry dog.”

To examine more complicated examples, the phrase "many big white Chinese dogs", is analyzed assuming left-to-right composition and that each adjective is also modeled as a linear transformation (matrix). The analysis is as follows:

$$\text{vec(many big white Chinese dogs)}=M\times B\times W\times C\times\text{vec(dogs)} \tag{3}$$

This analysis suggests that M is matrix for *many*, B is a matrix for *big*, W is a matrix for *white*, C is a matrix for *Chinese*, and vec(dogs) = is the base vector for *dogs.*

• Verbs: Verbs, especially transitive verbs, are modeled as more complex operators that act on pairs of noun vectors. To represent actions involving a subject and an object, we use the tensor product (⊗) to combine the noun vectors before applying the verb operator. This idea was explored in depth by Coecke et al. (2010) [14], who drew on concepts from category theory and linear algebra.

Example:

$$\text{dogs chase cats} = V \times (\text{vec(dogs)} \otimes \text{vec(cats)}) \quad (4)$$

In this case, V is the matrix representation of the verb chase, vec(dogs) and vec(cats) are the vectors of the subject "dogs" and object "cats". The two noun vectors are combined such that grammatical and semantic roles are preserved by forming tensor product.

4.3. Compositionality

This approach is grounded in the principle of compositionality, a core concept in linguistic semantics [16]. Compositionality states that the meaning of a complex expression, such as a sentence, is determined by the meanings of its parts (i.e., individual words) and the syntactic rules used to combine them. This aligns naturally with our mathematical framework, where:

• The meaning of a complex expression is formed by applying operators (matrices) to the vectors of the individual words.

• The syntax (such as the order of words) dictates how the components are combined: subject-verb-object, adjective-noun, etc., in a manner that reflects the structure of the sentence.

Following the compositional nature of language, we apply linear operators for modeling adjectives and verbs in order to introduce mathematical precision. The method for composing the matrices of adjectives and verbs with the noun vectors respects the meaning and the syntactic relationships between words [12,17].

As such this framework gives a formal, mathematically principled model of how word meanings are combined to form more encompassing meanings, all the while retaining all the compositionality of natural language.

5. Results and Illustrative Examples

This section shows expanded toy examples for demonstrating how operator theory can be applied to modelling compositional semantics in natural language. In other words, it aims to show that word meanings (encoded as vectors) can be systematically combined using matrices (operators) in a structured and interpretable way to produce phrase or sentence meanings.

In a simplified three-dimensional semantic space, in which each dimension represents an abstract semantic feature, we work. This toy model is quite simplified, but it is mathematically transparent and pedagogically clear.

5.1. Word Vectors: Noun Representations

Let our semantic space include three intuitive dimensions:

1. **Animacy** (ranging from inanimate to animate)
2. **Size** (small to large)
3. **Emotional valence** (negative to positive)

We define the following noun vectors:

- vec(dog) = [1.0, 0.7, 0.2] - A somewhat large, animate, neutral creature
- vec(cat) = [1.0, 0.5, 0.4] - Slightly smaller and more emotionally positive than dog
- vec(man) = [1.0, 0.9, 0.5] - Larger, clearly animate, and emotionally positive
- vec(ball) = [0.0, 0.4, 0.1] - Inanimate, small, and emotionally neutral

5.2. Adjectives as Operators

Adjectives are modeled as 3×3 matrices that transform noun vectors. Below are two example adjective matrices:

Angry (A_angry):

[[1, 0, 0], [0, 1, 0], [0.3, 0, 1.2]]

Small (A_small):

[[1, 0, 0], [0, 0.6, 0], [0, 0, 1]]

Examples:

$$\text{Angry dog} = A\_angry \times \text{vec(dog)} = [1.0, 0.7, 0.54] \quad (5)$$

$$\text{Small man} = A\_small \times \text{vec(man)} = [1.0, 0.54, 0.5] \quad (6)$$

5.3. Intransitive Verb Composition

Intransitive verbs like "sleeps" can also be modeled as 3×3 matrices acting directly on noun vectors.

Sleeps (V_sleeps):

[[1, 0, 0], [0, 0.9, 0], [0, 0.2, 1]]

$$\text{The cat sleeps} = V\_sleeps \times \text{vec(cat)} = [1.0, 0.45, 0.5] \quad (7)$$

5.4. Transitive Verb Composition

Transitive verbs like "chase" require two arguments. We use the tensor product to combine subject and object, resulting in a 9D vector. Then a 3×9 matrix maps this to a final 3D meaning vector.

Example:

$$vec(dog) \otimes vec(cat) = [1.0, 0.5, 0.4, 0.7, 0.35, 0.28, 0.2, 0.1, 0.08] \quad (8)$$

Chase (V_chases):
[[1, 0, 0, 0, 0.5, 0, 0, 0, 0],
[0, 1, 0, 0, 0, 0.3, 0, 0, 0],
[0, 0, 1, 0, 0, 0, 0.2, 0, 0]]
Result: Dogs chase cats = [1.175, 0.584, 0.44]

5.5. Nested Composition: Adjective + Noun + Verb

Example: The angry dog chases the small cat
Step-by-step:

$$\text{1. Modify noun vectors: } angry\_dog = A\_angry \times vec(dog),\ small\_cat = A\_small \times vec(cat) \quad (9)$$

$$\text{2. Combine: } angry\_dog \otimes small\_cat \quad (10)$$

$$\text{3. Apply verb matrix: } V\_chases \times (angry\_dog \otimes small\_cat) \quad (11)$$

The final result is a 3D vector encoding the meaning of the full sentence in compositional terms.

6. Conclusions

This paper introduced a mathematically grounded, operator-theoretic framework for modeling sentence-level meaning using linear algebraic structures. By conceptualizing content words, such as nouns, as vectors, and treating functional elements, particularly adjectives, intransitive verbs, and transitive verbs, as linear operators that transform these vectors, we presented a compositional model of meaning that reflects both syntactic dependencies and semantic dynamics. This representation, though simplified, offers a transparent, structured, and theoretically coherent way to understand how language conveys meaning through the systematic combination of its parts.

The proposed approach aligns closely with the Principle of Compositionality, a foundational idea in formal semantics, while incorporating mathematical techniques that allow for computational implementation. Although abstract in its current formulation, the model is modular and extensible, providing a flexible foundation that can be enriched in future research. Possible extensions include the integration of context-sensitive word embeddings, probabilistic and non-linear operators, and mechanisms for modeling contextuality, ambiguity, and discourse-level coherence. Such enhancements could make the model more robust and better suited for practical natural language processing (NLP) applications, while preserving its interpretability.

A central and distinguishing contribution of this study lies in its explicit commitment to sustainable language technology design. Rather than positioning sustainability as an afterthought or downstream concern, this work embeds it directly into the architectural choices of the semantic model itself. The use of interpretable, modular linear transformations supports transparency, auditability, and adaptability, features essential for the ethical deployment of computational systems in socially impactful domains. By focusing on compositional clarity and semantic transparency, the proposed framework contributes to the development of AI systems that are not only powerful but also responsibly designed.

Moreover, this operator-theoretic model serves as a bridge between symbolic linguistic theory and data-driven computational approaches, presenting a mathematically rigorous yet accessible platform for interdisciplinary collaboration. It invites further engagement from researchers in linguistics, artificial intelligence, cognitive science, and applied mathematics. This convergence of perspectives supports the broader goal of developing intelligent systems that reflect human language structures while aligning with global imperatives such as sustainability, equity, and long-term social responsibility.

In sum, this work contributes to a growing body of research that seeks to reimagine computational linguistics through the lens of interpretable, compositional, and ethically aware models. By grounding semantic modeling in linear operator theory and emphasizing transparency and sustainability, the study offers a forward-looking approach to both theoretical inquiry and technological development. It lays the groundwork for future explorations that can expand the framework's expressiveness, empirical validity, and societal relevance, ultimately advancing our ability to build language technologies that are not only effective but also aligned with human-centered values.

Limitations of the study

Despite its conceptual clarity and mathematical elegance, the model presented in this study exhibits several limitations. First, its reliance on linearity constrains its capacity to capture the inherently non-linear aspects of language, such as metaphor, implicature, and subtle shifts in meaning that emerge from complex contextual cues. Second, the model does not sufficiently address lexical ambiguity; words with multiple meanings often require context-aware or probabilistic modeling approaches for accurate interpretation, which fall outside the scope of simple linear transformations. Additionally, while the study employs simplified vector representations for illustrative purposes, real-world implementation would necessitate the use of large-scale linguistic corpora and the integration of machine learning techniques to construct reliable and semantically rich vector spaces. These limitations underscore the need for further research aimed at extending the framework to account for more sophisticated linguistic phenomena and improving its applicability in naturalistic language understanding.

Author Contributions

Conceptualization, M.S.Y. and F.A.; methodology, F.A.; software, F.A.; validation, M.S.Y., F.A., and H.I.; formal analysis, F.A.; investigation, M.S.Y.; resources, M.S.Y.; data curation, M.S.Y.; writing—original draft preparation, M.S.Y.; writing—review and editing, H.I.; visualization, F.A.; supervision, M.S.Y.; project administration, M.S.Y. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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