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# Neutrosophic soft set decision making for stock trending analysis

**Sudan Jha[1] · Raghvendra Kumar[2] · Le Hoang Son[3] · Jyotir Moy Chatterjee[4] · Manju Khari[5] · Navneet Yadav[6] · Florentin Smarandache[7]**

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**Abstract**
In this paper, we point out a major issue of stock market regarding trending scenario of trades where data exactness, accuracy of expressing data and uncertainty of values (closing point of the day) are lacked. We use neutrosophic soft sets (NSS) consisting of three factors (True, Uncertainty and False) to deal with exact state of data in several directions. A new approach based on NSS is proposed for stock value prediction based on real data from last 7 years. It calculates the stock price based on the factors like "open", "high", "low" and "adjacent close". The highest score value retrieved from the score function is used to determine which opening price and high price decide the closing price from the above mentioned four factors.

**Keywords** Neutrosophic soft sets · Soft sets · Stock trending · Stock parameters · Open · Close · High · Low · Adjacent close

## 1 Introduction

Many fields may not be effectively demonstrated by traditional expression since vulnerability is excessively muddled. They can be demonstrated by various distinctive methodologies including the likelihood theory, fuzzy set (FS) (Zadeh 1965), rough set (Pawlak 1982), neutrosophic set (NS) (Smarandache 2005) and soft set (Molodtsov 1999). NSs can deal with uncertain and conflicting data, which exist, regularly in conviction frameworks (Wang et al. 2005). In this manner, Maji proposed neutrosophic delicate set with operations, which is free of the challenges specified (Maji 2013). He additionally, connected to basic leadership issues (Maji 2012). After Maji, the investigations on the neutrosophic delicate set theory have been considered progressively (Broumi 2013; Broumi and Smarandache 2013). From scholastic perspective, the NS should be determined on the grounds that are connected to genuine applications (Deli 2017). In NS, indeterminacy is evaluated expressly and other membership degrees are free. This presumption is essential

✉ Le Hoang Son
sonlh@vnu.edu.vn

Sudan Jha
jhasudan@hotmail.com

Raghvendra Kumar
raghvendraagrawal7@gmail.com

Jyotir Moy Chatterjee
jyotirm4@gmail.com

Manju Khari
manjukhari@yahoo.co.in

Navneet Yadav
navneetyadavdr@gmail.com

Florentin Smarandache
fsmarandache@gmail.com

1 School of Computer Engineering, KIIT University, Bhubaneswar, India

2 Department of Computer Science and Engineering, LNCT College, Bhopal, India

3 VNU Information Technology Institute, Vietnam National University, Hanoi, Vietnam

4 School of Computer Science and Engineering, GD-RCET, Bhilai, India

5 Computer Science and Engineering Department, AIACTR, New Delhi, India

6 Electronics and Communication Engineering Department, Maharaja Agrasen Institute of Technology, New Delhi 110086, India

7 University of New Mexico, 705 Gurley Ave., Gallup, NM 87301, USA

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in numerous applications, for example, data combination in which the information is consolidated from various sensors. As of late, NSs had for the most part been connected to picture preparing (Cheng and Guo 2008; Guo and Cheng 2009) (Table 1).

Along these lines, Wang et al. (2010) proposed a single-valued NS (SVNS) and set-theoretic operations and properties. Ye (2013a) proposed similarity measures between interim NSs and connected them to multi-criteria decision-making issues. On one hand, a SVNS is an example of a NS, which gives us an extra probability to deal with vulnerability, inadequacy and conflicting data. It would be more appropriate to apply uncertain and conflicting data measures in decision-making. In any case, the connector in the FS is portrayed concerning *T*, i.e. participation just; hereafter the information of indeterminacy and non-enrollment is lost. While in the SVNS, they can be characterized regarding any of them. Thus, the idea of SVNSs is broader and overcomes the previously mentioned issues. Then, SVNSs can be utilized for applications to handle dubious, imprecision and conflicting data. Because of its capacity, SVNS is reasonable for catching loose, indeterminate, and conflicting data in the multi-criteria decision-making.

Broumi and Smarandache (2013) presented correlation coefficients of interval valued NS (INS). Ye (2013b) exhibited the correlation coefficient of single-valued NSs (SVNSs). Ye (2014a, b) presented the idea of streamlined NSs (SNSs), which are a subclass of NSs, and characterized operational laws of SNSs. The authors proposed some accumulation administrators, including a rearranged Neutrosophic weighted number juggling normal administrator and an improved neutrosophic weighted geometric normal administrator. Peng et al. (2014, 2015) showed another outranking approach for multi-criteria decision-making (MCDM) to an improved neutrosophic condition, where reality enrollment degree, indeterminacy-participation degree and misrepresentation participation degree for every component are singleton sub-sets in Zadeh (1965). Ma et al. (2017) proposed cosine similarity measures of SNSs whereas Deli and Şubaş (2017) presented a medicinal treatment determination technique in view of an interval neutrosophic phonetic condition, in which criteria and decision-producers are doled out various levels of need. Ye (2015) introduced a philosophy for tackling multi-trait decision-making issues with SVN-numbers. Pramanik et al. (2017) proposed new vector similitude measures of single valued and interval NSs by hybridizing the ideas of Dice and cosine closeness measures. Mostly often, we see that data lack exactness, lack accuracy of expression. It is indeed necessary to use NS and its extension for dealing with these factors (Thanh et al. 2018a, b; Ali et al. 2017, 2018a, b, c; Nguyen et al. 2018; Broumi et al. 2017a, b; Dey et al. 2018; Thao et al. 2018; Thong et al. 2018; Son et al. 2017; Son and Thong 2017; Son 2015, 2016, 2017; Thong and Son 2015, 2016a, b, c; Angelov and Sotirov 2015).

This paper proposes a model for stock trend prediction based on neutrosophic soft set (NSS). Sections 2 and 3 present preliminary and the proposal. Sections 4 and 5 dive discussion, conclusions and further research respectively.

## 2 Background

**Definition 1** (Molodtsov 1999) A soft set is defined as below,

$$f : S \rightarrow \text{power\_of (U)}$$

where, $U$ and $S$ are the universal and soft sets having parameters like $R$ = redundancy contradiction, $Inc$ = inconsistency, $In$ = incompleteness, $U_n$ = uncertainty, $V$ = vagueness, $A$ = ambiguity, and $I$ = imprecision undefined. Here *f*is a mapping function to *S*.

**Definition 2** (Molodtsov 1999) Let *T* be the fuzzy soft set and ℸ be the Cross so that the Fusion and Cross can be defined as

$(\text{Ʈ} \cup \text{T})(x) = \text{Ʈ}(x) \vee \text{T}(x)$
$(\text{Ʈ} \cap \text{T})(x) = \text{Ʈ}(x) \wedge \text{T}(x)$
$\text{T} \subseteq \text{Ʈ}$
if $\text{T}(x) \leq \text{Ʈ}(x), x \in U$

where *T* denotes the family of fuzzy soft sets T (upper case), and ℸ is the Cross to define the Fusion.

**Definition 3** (Molodtsov 1999) If (*f*, X) and (*f*′, Y) ∈ U then (*f*, X) is fuzzy soft subset of (*f*′, Y) or (*f*, X) ⊆ (*f*′, Y) if

1. X ⊆ Y
2. f(a) ≤ f(a), a ∈ A.

**Table 1** Neutrosophic soft set (*f*, A) representing the stock-trending

| ST | High price | Low price | Adj close price |
|---|---|---|---|
| Para1 | (35.57571, 35.07286, 0, 35.56) | (37.17857, 36.53286, 37.03143) | (38.10714, 36.6, 38.06714) |
| Para2 | (35.87714, 34.93572, 35.34) | (37.61286, 36.67857, 36.95429) | (36.87714, 35.53286, 36.57) |
| Para3 | (35.41286, 34.53857, 35.29572) | (36.89286, 28.46429, 35.17857) | (35.22429, 32.17286, 33.69429) |
| Para4 | (35.60714, 34.70857, 34.94143) | (36.37857, 35.50428, 36.28429) | (37.12714, 35.78571, 36.64571) |

where (*f*, X) is fuzzy soft set. The difference between (*f*, A) and (*f*, X) is that (*f*, A) represents Universal Neutrosophic Set whereas (*f*, X) represents the fuzzy soft set.
All neutrosophic sets of X are denoted $f_N$ (X).

**Definition 4** (Wang et al. 2010) NSS *X* is contained in NSS *Y* if

1. X⊆Y
2. TX(x) ≤ TY (x), IX(x) ≤ IY (x), FX(x) ≥ FY (x) for all x ∈ X.

**Definition 5** (Wang et al. 2010) The complement of NSS is a NSS (*f*c, ¬ X):

1. $f_c$: ¬ A → *f*N (X),
2. *f*c(a) = < x, T*f* c (x) = *ff* (x), I*f* c (x) = 1 − I*f* (x), *ff* c (x) = T*f* (x)>, a ∈ A and x ∈ X.

**Definition 6** (Wang et al. 2010) Assume *Z* = < *x, TX(x), IX(x), f″X(x)* > and *A* ≤ *x*, $T_A$ *(x)*, $I_A$ *(x)*, *f″A (x)* > is NSS. We have

X∨A ≤ x, max(TX(x), $T_A$ (x)), max(IX(x), $I_A$ (x)), min(*f″*X(x), *f″*A (x))>

X∧A ≤ x, min(TX(x), $T_A$ (x)), min(IX(x), $I_A$ (x)), max(*f″*X(x), *f″*A (x))>

**Definition 7** (Wang et al. 2010) A set Z - ¬(*f*, X) is said to be non-empty over U if $T_f(a) = 0, I_f(a): 0, f_f(a): 1, a \in A$.

**Definition 8** (Wang et al. 2010) Fuzzy set (*f*, A) is a Universal Neutrosophic Set over *U* if $T_f$ (a) = 1, $I_f$ (a) : 1, $F_f$ (a) : 0 for all a ∈ A.where (*f*, A) represents a fuzzy set over the universal neutrosophic set.

## 3 Proposed model

We now derive Fusion, Cross and Structure as below:

(a) Fusion of NSSs (f, A) and (*f″*, B) is (H, C) = (f, A) ∪ (*f″*, B) over U with C = A ∪ B and H(C) = f(C) if c ∈ A\B.
(b) Cross of NSSs (f, A) and (g, B) is (H, C) = (f, A) ∩ (g, B) with C = A∩B, H(c) = F(c)∧G(c), c ∈ C.
(c) Relation is computed by the following steps:

1. Let L ⊆ A × B: $L_e$(a, b) = *f*(a) ∧*f″*(b), a ∈ A, b ∈ B, $L_e$: K → FN (U).
2. $L_{f1}$ in relation with (*f*, A) to (*f″*, B) and $L_{f2}$ in relation with (*f*, B) to (*f″*, C). Then, the composition of relations $L_{f1}$ and $L_{f2}$ is defined by ($L_{f1}$∘ $L_{f2}$) (a, c) = $L_{f1}$ (a, b) ∧ $L_{f2}$ (b, c), a ∈ A, b ∈ B, c ∈ C.
3. The *fusion* and *cross* of $L_{f1}$ and $L_{f2}$ of (*f*, A) and (*f″*, B) over U are:

fusion → $L_{f1}$ ∪ $L_{f2}$ (a, b) = MAX{$L_{f1}$ (a, b), $L_{f2}$ (a, b)},
cross → $L_{f1}$ ∩ $L_{f2}$ (a, b) = MIN {$L_{f1}$ (a, b), $L_{f2}$ (a, b)}.

4. The MAX→MIN→MAX composition for set is expressed with the relation L ∘ A.
5. The associative (AL), non-deterministic (NL) and non-associative (NAL) functions can be derived as below:

AL∘A(y) = ∪x[AL(x) ∧ AA(x, y)],
NL∘A(y) = ∪x[NL(x) ∧ NA(x, y)],
NAL∘A(y) = ∧x[NAL(x) ∨ NALA(x, y)].

6. (*f*, A) conclusively can be defined as: V (F, A) = TA + (1 − UA)—FA where TA → *True* value, UA → *Uncertain* value and FA → denotes the *False* value. The TA, UA and FA are the values with respect to (F, A).
7. Score function → S1 = V (F, A) − V (G, B). The score function for (L,A) → $TA_i - Ua_i * FA_i$.

Now, trade trends are identified using NSSs with variables below: *Date, Open*—opening price of particular date, *High*—highest price at particular date, *Low*—lowest price at particular date, *Close*—closing price at particular date, *Adj Close*—adj. close price at particular date, *Volume*—volume of stock traded.NSS is applied for identification, detection and determination of which stock is getting affected from various parameters. The effect *E* relates to a closing price *C*.

**NSS Algorithm for determining the decision for closing of stock trending**
**Input:** variables
**Output**: Actual and Predicated Values
**Algorithm:**

1. *Split the data into train and test NSS data*
2. *The Date is the features and the Open price is our target values which need to be predicted*
   *X(features) = [Year, Month, Day], y(target) = [Open]*
3. *Feature scaling is done on data for faster convergence rate of algorithms and to maintain standardization in data*
4. *Function to plot graph is written which takes dataset as parameters and plots the graph*
5. *Train the model using Regression*
6. *The Train data are fitted into the algorithm*
7. *The model's accuracy is then computed by giving Test data as input and evaluating the predicted result against the known value from Test data*
8. *The graph is plotted between Actual value vs. Predicted value*

**Table 2** Obtaining the relation $L$

| Factors | Open | High | Low | Close | Adj close |
|---|---|---|---|---|---|
| Para1 | 12.327143 | 12.368571 | 11.7 | 11.971429 | 10.770167 |
| Para2 | 12.007143 | 12.278571 | 11.97 | 12.237143 | 11.00922 |
| Para3 | 12.252857 | 12.314285 | 12.05 | 12.15 | 10.930819 |
| Para4 | 12.28 | 12.361428 | 12.18 | 12.21 | 10.984798 |

**Table 3** Performing the transformation operation using relation $T$

| Factors | Open | High | Low | Close |
|---|---|---|---|---|
| Para1 | 12.444285 | 12.642858 | 12.29 | 12.321428 |
| Para2 | 12.444285 | 12.481428 | 12.141429 | 12.197143 |
| Para3 | 12.328571 | 12.378572 | 12.218572 | 12.277143 |
| Para4 | 12.347143 | 12.355714 | 12.178572 | 12.221429 |

## 4 Result and discussion

There are sets of 7 years which include the various parameters to predict the next day opening value (https://in.finance.yahoo.com). The parameters achieved here are High (highest price at particular date), Low (lowest price at particular date) and Adj Close (adj. close price at particular date) Let the possible reasons relating to these ups and downs be Gold Price ($g_1$), Petrol Price ($pp_1$), Interest Rates ($ir_1$), the value of the US dollar ($USD_1$) and Economic/Political shocks ($sh_1$). The following demonstrates the processing of the algorithm and achieved results.

1. Parameters of stock are sent to association $Q$.
2. Trading relating to open and closing is given in Table 2.
3. Structure $T$ of "open and close" and "high and low" is found in Step 5 (Table 3).
4. Supplement of Table 1 is shown in Table 4.
5. Supplement of Table 2 is in Table 5.
6. Estimation of Tables 4 and 5 is in Table 6.
7. Outputs of Tables 3 and 6 are given in Tables 7 and 8 independently.
8. Score associated for the qualities in Tables 7 and 8 is found in Table 9.
9. Score for Table 3 is in Table 10.
10. Find highest score for stock closing affected by different opening and closing.

From all the columns, we extract Date and Open from the table to make a new dataset.

| Before decomposition of date | |
|---|---|
| Date (YYYY-MM-DD) (date object) | Open (float) |

**Table 4** The complement of $Q \circ R$

| ST | High price | Low price | Adj close price |
|---|---|---|---|
| Para1 | (37.02143, 35.79286, 35.84857, 32.25138) | (36.25714, 35.09286, 35.61857, 32.04446) | (35.98571, 34.64143, 34.74286, 31.25662) |
| Para2 | (35.85429, 34.6, 35.78714, 32.19612) | (36.26571, 35.33857, 36.21571, 32.58168) | (37.02143, 36.28714, 36.32571, 32.68065) |
| Para3 | (37.12143, 36.5, 37.09857, 33.37596) | (38.25, 37.23286, 38.17857, 34.34757) | (38.98571, 38.5, 38.83857, 34.94136) |
| Para4 | (39.28571, 38.77428, 39.15286, 35.22411) | (39.85857, 38.39, 38.59572, 34.72287) | (39.42429, 38.78571, 39.12143, 35.19582) |

**Table 5** The complement of R′

| R′ | High | Low | Close | Adj close |
|---|---|---|---|---|
| Para1 | (39.23714, 38.27143, 38.71) | (39.02857, 38.3, 38.42857) | (38.61, 37.97286, 38.1) | (12.184286, 12.042857, 12.1, 10.885842) |
| Para2 | (39.23714, 38.27143, 38.71) | (39.02857, 38.3, 38.42857) | (38.61, 37.97286, 38.1) | (12.184286, 12.042857, 12.1, 10.885842) |
| Para3 | (12.234285, 12.081429, 12.185715, 10.962953) | (12.231428, 12.111428, 12.172857, 10.951384) | (12.201428, 12.094286, 12.118571, 10.902546) | (12.308572, 12.022857, 12.271428, 11.040065) |
| Para4 | (12.784286, 12.28, 12.742857, 11.46419) | (12.972857, 12.647142, 12.787143, 11.504031) | (12.905714, 12.692857, 12.724286, 11.447481) | (12.857142, 12.515715, 12.644286, 11.375507) |

**Table 6** Composition values of Tables 4 and 5

| R′ | High | Low | Close | Adj close |
|---|---|---|---|---|
| Para1 | (12.44, 11.915714, 11.99, 10.786877) | (12.228572, 11.857142, 12.087143, 10.874274) | (12.615714, 11.964286, 12.437143, 11.189151) | (12.505714, 12.172857, 12.201428, 10.977087) |
| Para2 | (12.664286, 12.251429, 12.331429, 11.094046) | (12.615714, 12.485714, 12.598572, 11.334381) | (12.71, 12.492857, 12.531428, 11.273974) | (12.674286, 12.494286, 12.571428, 11.309962) |
| Para3 | (12.692857, 12.485714, 12.567142, 11.306105) | (12.855714, 12.57, 12.838572, 11.550298) | (12.201428, 12.094286, 12.118571, 10.902546) | (12.308572, 12.022857, 12.271428, 11.040065) |
| Para4 | (12.784286, 12.28, 12.742857, 11.46419) | (12.972857, 12.647142, 12.787143, 11.504031) | (12.905714, 12.692857, 12.724286, 11.447481) | (12.857142, 12.515715, 12.644286, 11.375507) |

| After decomposition of date | | | |
|---|---|---|---|
| Year (YYYY) integer | Month (MM) integer | Day (DD) integer | Open (float) |

Now, let us take Para = {para1, para2, para3, para4} where para1 = $g_1$, para2 = $pp_1$, para3 = $ir_1$, and para4 = $USD_1$ as the universal set where $g_1$, $pp_1$, $ir_1$, $USD_1$ $sh_1$ are Gold Price ($g_1$), Petrol Price ($pp_1$), Interest Rates ($ir_1$), the value of the US dollar ($USD_1$) and Economic/Political shocks ($sh_1$) as explained in the previous statements.

Next, consider the set $K = \{k1, k2, k3, k4\}$ as universal set where *k1, k2, k3, k4* represent consequence/results like open, high, low and adj close respectively and the set $F = \{f_1, f_2, f_3, f_4\}$ where $f_1$, $f_2$, $f_3$ and $f_4$ represent the faster convergence rate, actual value, trending value and predicted value respectively.

We construct stock-trending relation and trending-close relation as follows:

F (para1) = {k1/(0.7, 0.4, 0.1), k2/(0.8, 0.6, 0.7), k3/(0.4, 0.8, 0.5)},

F (para2) = {k1/(0.6, 0.5, 0.3), k2/(0.6, 0.5, 0.2), k3/(0.7, 0.9, 0.0)},

F (para3) = {k1/(0.8, 0.4, 0.2), k2/(0.5, 0.1, 0.5), k3/(1.0, 0.5, 1.0)},

F (para4) = {k1/(0.4, 0.6, 0.3), k2/(0.5, 0.4, 0.8), k3/(0.5, 0.6, 0.9)}.

(*f*, A) results into a collection of generalized stock-trending in the stock market. It represents stock-trending relation given by,

Next, G(k1) = {f1/(37.59,36.95714,37.44143), f2/(37.85714,36.62857,36.90857), f3/(36.64,35.64286,36.26), f4/(34.92857,33.05,34.61714)}, G(k2) = {f1/(36.59714,35.38714,36.31714), f2/(36.93572,35.75143,36.05143), f3/(34.83571,33.74429,33.96571), f4/(36.13143,34.97857,35.47714)}, G(k4) = {f1/(37.82857,37.19,37.70714,33.92345), f2/(37.93572,37.20153,37.58857,33.81678), f3/(37.41429,36.37571,36.56572,32.89656)}. We realize $\{G(f1), G(f2), G(f3)\}$ of all $S$ where $G: S \rightarrow FN(D)$. Thus, $(G, S)$ is represented by a relation matrix (stock_high-stock_lowmatrix) R given in Table 2.

The trading knowledge relating the parameters with the set of open and closing values under consideration is in Table 2. We perform transformation operation $Q \circ R$ to get the stocks' high and low value relation in Table 3.

Likewise, $Q \circ R$ is calculated to give the stocks' high and low value relation $T$. These set of values are now complimented in Tables 4 and 5. The composition values are calculated in Table 6.

Table 6 uses the composition of relations $L_{f1}$ and $L_{f2}$ which are defined by,

$(L_{f1} \circ L_{f2})(a, c) = L_{f1}(a, b) \wedge L_{f2}(b, c),\ a \in A,\ b \in B,\ c \in C.$

Value functions for Tables 3 and 6 are calculated in Tables 7 and 8.

**Table 7** The value function for cross of $L_{f1}(a, b) \wedge L_{f2}(b, c)$

| Value | High | Low | Close | Adj close |
|---|---|---|---|---|
| Para1 | 12.78, 12.28 | 12.74 | 11.46 | Para1 |
| Para2 | 12.97 | 12.64 | 12.78 | 11.50 |
| Para3 | 12.90 | 12.69 | 12.72 | 11.44 |
| Para4 | 12.85 | 12.51 | 12.64 | 11.37 |

**Table 8** The value function for fusion of $L_{f1}(a, b) \cup L_{f2}(b, c)$

| Value | High | Low | Close | Adj close |
|---|---|---|---|---|
| Para1 | 13.68 | 12.38 | 12.34 | 12.46 |
| Para2 | 12.79 | 12.46 | 12.78 | 12.39 |
| Para3 | 12.60 | 12.46 | 12.27 | 11.44 |
| Para4 | 12.42 | 12.24 | 12.46 | 11.37 |

**Table 9** Score function for Tables 7 and 8

| Value | High | Low | Close | Adj close |
|---|---|---|---|---|
| Para1 | −0.01 | −0.1 | −0.04 | 0.3 |
| Para2 | 0.4 | 0.3 | 0.7 | 0.6 |
| Para3 | 0.1 | 0.3 | 0.5 | 0.5 |
| Para4 | −0.7 | −0.03 | −0.04 | 0 |

**Table 10** Score function for the Table 3

| Value | High | Low | Close | Adj close |
|---|---|---|---|---|
| Para1 | 0.14 | 0.3 | 0.35 | 0.65 |
| Para2 | 0.46 | 0.46 | 0.55 | 0.45 |
| Para3 | 0.55 | 0.55 | 0.75 | 0.38 |
| Para4 | 0.08 | 0.2 | 0.18 | 0.38 |

Score function $(L,A) \rightarrow TA_i - Ua_i * FA_i$ for Table 3 is in Table 10. As explained earlier, the score function comprises of values of high, low, close and Adjclose. The closest score function is depicted below.

It is clear from Tables 9 and 10 that stock price at para1 and para4 are absolute alteration due to *k1, k2, k3, k4* represent consequence/results like open, high, low and adj close respectively.

From Table 3, $Q \circ R$ is performed to give the stocks' high and low value relation. These set of values are now complimented in Tables 4 and 5.

## 5 Conclusion

This paper applied neutrosophic soft sets to predict the stock price. Based upon the factors like open, high, low and adj close, and the score value, we have developed a technique to determine which opening price and high price decide the closing price from what factors. Since there is no competing interest exists in the field of applied NSS, there are various scopes using fuzzy theory to determine the predictability of stock parameterized values at the specific time. In our work, we have focused on the value for the opening and closing points. The work can be extended to trace the decision at any point of time. Yet, it indeed needs huge datasets for testing the model rigorously. We keep this as the reference for the future.

### Compliance with ethical standards

**Conflict of interest** The authors declare that they do not have any conflict of interests. This research does not involve any human or animal participation. All authors have checked and agreed the submission.

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