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P. Revathi
Annamalai University

K. Chitirakala
M. Kumarasamy College of Engineering

A. Vadivel
Annamalai University

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Neutrosophic Soft Contra e-Continuous Maps, Contra e-Irresolute Maps and Application using Distance Measure

[1]P. Revathi, [2]K. Chitirakala and [3]A. Vadivel

[1]Government Polytechnic College
Kuduveli, Chidambaram - 608 305
India
revathimathsau@gmail.com

[1]Mathematics Section (FEAT)
Annamalai University
Annamalai Nagar - 608 002
India

[2]Department of Mathematics
M.Kumarasamy College of Engineering
Karur - 639 113, India
chitrakalalaksana@gmail.com

[3]Department of Mathematics
Arignar Anna Government Arts College
Namakkal - 637 002, India
avmaths@gmail.com

[2,3] Department of Mathematics
Annamalai University
Annamalai Nagar - 608 002, India

*Corresponding Authors: A.Vadivel and K.Chitirakala

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Abstract

We introduce and investigate neutrosophic soft contra e-continuous maps and contra e-irresolute maps in neutrosophic soft topological spaces with examples. Also, neutrosophic soft contra e-continuous maps are compared with neutrosophic soft continuous maps, δ-continuous maps, δ-semi continuous maps, δ-pre continuous maps and e^* continuous maps in neutrosophic soft topological spaces. We derive some useful results and properties related to them. An application in decision making problem using distance measure is given. An example of a candidate selection from a company interview is formulated as neutrosophic soft model problem and the hamming distance measure is applied to calculate the distance between the interview candidates and the ideal candidate. The candidate having less distance with the ideal solution is the desirable candidate.

Keywords: Neutrosophic soft e-closed sets; Neutrosophic soft contra e-continuous maps and neutrosophic soft contra e-irresolute maps; Hamming distance

MSC 2010 No.: 03E72, 54C05, 54C10

1. Introduction and Preliminaries

Zadeh (1965) introduced the fuzzy set and Chang (1968) developed its topological structure. Intuitionistic fuzzy set was initiated by Atanassov (1986) and Coker (1997) developed its topological structure. Molodtsov (1999) introduced the soft set theory. The soft topological spaces were established by Shabir and Naz (2011). The neutrosophic set was introduced by Smarandache (2005) and Salama and Alblowi (2012) developed its topological structure. The neutrosophic soft sets were defined by Maji (2013), modified by Deli and Broumi (2015) and Bera and Mahapatra (2017) developed its topological structures.

The concept of δ-open sets was given by Saha (1987) in fuzzy topological spaces, Vadivel et al. (2021) in neutrosophic topological spaces and Acikgoz and Esenbel (2019) in neutrosophic soft topological spaces. The concept of e-open sets were introduced and also studied by Ekici (2007, 2008a, 2008b, 2008c, 2008c, 2008d, 2009) in a general topology, Seenivasan and Kamala (2014) in fuzzy topological spaces, Chandrasekar et al. (2018) in intuitionistic fuzzy topological spaces, Revathi et al. (2021, 2022) in neutrosophic soft topological spaces. Vadivel et al. (2021a, 2021b) developed the concept of neutrosophic e-continuity and e-irresolute maps. The concept of contra continuous function in general topology was introduced by Dontchev (1996). Vadivel et al. (2020) introduced generalized fuzzy contra e-continuous functions in fuzzy topological spaces. Arockiarani (2014, 2017) and Vadivel and John Sundar (2021) introduced distance measures and studied its application in multi attribute decision making in neutrosophic soft sets and neutrosophic sets.

In this article, the concept of neutrosophic soft contra e-continuous maps are introduced in neutrosophic soft topological spaces and their basic properties are analyzed with examples. Added to that, we introduce and discuss some characterizations and properties of neutrosophic soft contra e-irresolute maps. An application involving decision making problem using distance measure is also discussed.

The basic definitions, properties and theorems of neutrosophic soft (in short N_sS) topological spaces needed in this paper are shown in Acikgoz and Esenbel (2019), Bera and Mahapatra (2017), Deli and Broumi (2015), Evanzalin et al. (2020), Maji (2013), Revathi et al. (2021, 2022) and Arockiarani (2014, 2017).

2. Neutrosophic Soft Contra e-continuous Maps in N_sSts

In this section, N_sS contra e-continuous maps are introduced and some of its properties are discussed.

Definition 2.1.

A N_sSt $(\mathfrak{M}, \tau, \Lambda)$ is called a N_sS $eU_{\frac{1}{2}}$-space, if every N_sSeos in $\mathfrak{M}$ is a N_sSos in $\mathfrak{M}$.

Definition 2.2.

A mapping $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \to (\mathfrak{N}, \sigma, \Lambda)$ is N_sS contra *e-continuous* (respectively, *continuous, δ continuous, δ-semi continuous, δ-pre continuous and* e^**-continuous*) (briefly, $N_sScontraeCts$ (respectively, $N_sScontraCts$, $N_sScontra\delta Cts$, $N_sScontra\delta\mathcal{S}Cts$, $N_sScontra\delta\mathcal{P}Cts$ and $N_sScontrae^*Cts$)) if the inverse image of every N_sSos of $(\mathfrak{N}, \sigma, \Lambda)$ is N_sSec (respectively, N_sSc, $N_sS\delta c$, $N_sS\delta\mathcal{S}c$, $N_sS\delta\mathcal{P}c$ and N_sSe^*c) set in $(\mathfrak{M}, \tau, \Lambda)$.

Example 2.1.

Let $\mathfrak{M} = \{\mathfrak{m}_1, \mathfrak{m}_2, \mathfrak{m}_3\} = \{\mathfrak{n}_1, \mathfrak{n}_2, \mathfrak{n}_3\} = \mathfrak{N}, \Lambda = \{q_1, q_2\}$ and N_sSs's $(\tilde{K}_1, \Lambda), (\tilde{K}_2, \Lambda), (\tilde{K}_3, \Lambda)$, $(\tilde{K}_4, \Lambda)$, $(\tilde{K}_5, \Lambda)$ & $(\tilde{K}_6, \Lambda)$ in $\mathfrak{M}$ and $(\tilde{L}_1, \Lambda)$ in $\mathfrak{N}$ are defined as

$$\begin{aligned}
(\tilde{K}_1, q_1) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{1}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0}), (\frac{\mu_{\mathfrak{m}_2}}{0}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0}), (\frac{\mu_{\mathfrak{m}_3}}{0.2}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.7})\rangle,\\
(\tilde{K}_1, q_2) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0.9}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.1}), (\frac{\mu_{\mathfrak{m}_2}}{0.9}, \frac{\sigma_{\mathfrak{m}_2}}{0.6}, \frac{\nu_{\mathfrak{m}_2}}{0.2}), (\frac{\mu_{\mathfrak{m}_3}}{0.3}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.8})\rangle,\\
(\tilde{K}_2, q_1) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{1}), (\frac{\mu_{\mathfrak{m}_2}}{1}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0}), (\frac{\mu_{\mathfrak{m}_3}}{0}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{1})\rangle,\\
(\tilde{K}_2, q_2) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0.1}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.8}), (\frac{\mu_{\mathfrak{m}_2}}{0.1}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.4}), (\frac{\mu_{\mathfrak{m}_3}}{0}, \frac{\sigma_{\mathfrak{m}_3}}{0.4}, \frac{\nu_{\mathfrak{m}_3}}{0.9})\rangle,\\
(\tilde{K}_3, q_1) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{1}), (\frac{\mu_{\mathfrak{m}_2}}{0}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0}), (\frac{\mu_{\mathfrak{m}_3}}{0}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{1})\rangle,\\
(\tilde{K}_3, q_2) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0.1}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.8}), (\frac{\mu_{\mathfrak{m}_2}}{0.1}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.4}), (\frac{\mu_{\mathfrak{m}_3}}{0}, \frac{\sigma_{\mathfrak{m}_3}}{0.4}, \frac{\nu_{\mathfrak{m}_3}}{0.9})\rangle,\\
(\tilde{K}_4, q_1) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{1}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0}), (\frac{\mu_{\mathfrak{m}_2}}{1}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0}), (\frac{\mu_{\mathfrak{m}_3}}{0.2}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.7})\rangle,\\
(\tilde{K}_4, q_2) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0.9}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.1}), (\frac{\mu_{\mathfrak{m}_2}}{0.9}, \frac{\sigma_{\mathfrak{m}_2}}{0.6}, \frac{\nu_{\mathfrak{m}_2}}{0.2}), (\frac{\mu_{\mathfrak{m}_3}}{0.3}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.8})\rangle,\\
(\tilde{K}_5, q_1) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{1}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0}), (\frac{\mu_{\mathfrak{m}_2}}{0}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.2}), (\frac{\mu_{\mathfrak{m}_3}}{0}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0})\rangle,\\
(\tilde{K}_5, q_2) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0.8}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.2}), (\frac{\mu_{\mathfrak{m}_2}}{0.2}, \frac{\sigma_{\mathfrak{m}_2}}{0.4}, \frac{\nu_{\mathfrak{m}_2}}{0.3}), (\frac{\mu_{\mathfrak{m}_3}}{0.3}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.1})\rangle,\\
(\tilde{K}_6, q_1) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{1}), (\frac{\mu_{\mathfrak{m}_2}}{0.9}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0}), (\frac{\mu_{\mathfrak{m}_3}}{0.3}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.2})\rangle,\\
(\tilde{K}_6, q_2) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0.3}, \frac{\sigma_{\mathfrak{m}_1}}{0.4}, \frac{\nu_{\mathfrak{m}_1}}{0.7}), (\frac{\mu_{\mathfrak{m}_2}}{0.8}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.2}), (\frac{\mu_{\mathfrak{m}_3}}{0.4}, \frac{\sigma_{\mathfrak{m}_3}}{0.6}, \frac{\nu_{\mathfrak{m}_3}}{0.4})\rangle,\\
(\tilde{L}_1, q_1) &= \langle(\frac{\mu_{\mathfrak{n}_1}}{0}, \frac{\sigma_{\mathfrak{n}_1}}{0.5}, \frac{\nu_{\mathfrak{n}_1}}{1}), (\frac{\mu_{\mathfrak{n}_2}}{0.9}, \frac{\sigma_{\mathfrak{n}_2}}{0.5}, \frac{\nu_{\mathfrak{n}_2}}{0}), (\frac{\mu_{\mathfrak{n}_3}}{0.3}, \frac{\sigma_{\mathfrak{n}_3}}{0.5}, \frac{\nu_{\mathfrak{n}_3}}{0.2})\rangle,\\
(\tilde{L}_1, q_2) &= \langle(\frac{\mu_{\mathfrak{n}_1}}{0.3}, \frac{\sigma_{\mathfrak{n}_1}}{0.4}, \frac{\nu_{\mathfrak{n}_1}}{0.7}), (\frac{\mu_{\mathfrak{n}_2}}{0.8}, \frac{\sigma_{\mathfrak{n}_2}}{0.5}, \frac{\nu_{\mathfrak{n}_2}}{0.2}), (\frac{\mu_{\mathfrak{n}_3}}{0.4}, \frac{\sigma_{\mathfrak{n}_3}}{0.6}, \frac{\nu_{\mathfrak{n}_3}}{0.4})\rangle.
\end{aligned}$$

Then, we have $\tau = \{0_{(\mathfrak{M},\Lambda)}, 1_{(\mathfrak{M},\Lambda)}, (\tilde{K}_1, \Lambda), (\tilde{K}_2, \Lambda), (\tilde{K}_3, \Lambda), (\tilde{K}_4, \Lambda)\}$ and $\sigma = \{0_{(\mathfrak{N},\Lambda)}, 1_{(\mathfrak{N},\Lambda)}$, $(\tilde{L}_1, \Lambda)\}$. Consider an identity mapping $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \to (\mathfrak{N}, \sigma, \Lambda)$. Then $\mathfrak{h}$ is $N_sScontraeCts$.

Proposition 2.1.

The following statements are hold but the converse need not be true.
(i) Each $N_sScontra\delta Cts$ is a $N_sScontraCts$.
(ii) Each $N_sScontraCts$ is a $N_sScontra\delta\mathcal{S}Cts$.
(iii) Each $N_sScontraCts$ is a $N_sScontra\delta\mathcal{P}Cts$.

(iv) Each $N_sScontra\delta\mathcal{S}Cts$ is a $N_sScontraeCts$.
(v) Each $N_sScontra\delta\mathcal{P}Cts$ is a $N_sScontraeCts$.
(vi) Each $N_sScontraeCts$ is a $N_sScontrae^*Cts$.

Proof:

(i) Let $(\tilde{L}, \Lambda)$ be a N_sSos in $\mathfrak{N}$. Since $\mathfrak{h}$ is $N_sScontra\delta Cts$, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is $N_sS\delta cs$ in $\mathfrak{N}$. Since all $N_sS\delta cs$ are N_sScs, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is N_sScs in $\mathfrak{N}$. Hence, $\mathfrak{h}$ is a $N_sScontraCts$.
(ii) Let $(\tilde{L}, \Lambda)$ be a N_sSos in $\mathfrak{N}$. Since $\mathfrak{h}$ is $N_sScontraCts$, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is N_sScs in $\mathfrak{N}$. Since all N_sScs are $N_sS\delta\mathcal{S}cs$, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is $N_sS\delta\mathcal{S}cs$ in $\mathfrak{N}$. Hence, $\mathfrak{h}$ is a $N_sScontra\delta\mathcal{S}Cts$.
(iii) Let $(\tilde{L}, \Lambda)$ be a N_sSos in $\mathfrak{N}$. Since $\mathfrak{h}$ is $N_sScontraCts$, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is N_sScs in $\mathfrak{N}$. Since all N_sScs are $N_sS\delta\mathcal{P}cs$, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is $N_sS\delta\mathcal{P}cs$ in $\mathfrak{N}$. Hence, $\mathfrak{h}$ is a $N_sScontra\delta\mathcal{P}Cts$.
(iv) Let $(\tilde{L}, \Lambda)$ be a N_sSos in $\mathfrak{N}$. Since $\mathfrak{h}$ is $N_sScontra\delta\mathcal{S}Cts$, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a $N_sS\delta\mathcal{S}cs$ in $\mathfrak{N}$. Since every $N_sS\delta cs$ is a N_sSecs, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sSecs in $\mathfrak{N}$. Hence, $\mathfrak{h}$ is a $N_sScontraeCts$.
(v) Let $(\tilde{L}, \Lambda)$ be a N_sSos in $\mathfrak{N}$. Since $\mathfrak{h}$ is $N_sScontra\delta\mathcal{P}Cts$, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a $N_sS\delta\mathcal{P}cs$ in $\mathfrak{N}$. Since every $N_sS\delta\mathcal{P}cs$ is a N_sSecs, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sSecs in $\mathfrak{N}$. Hence, $\mathfrak{h}$ is a $N_sScontraeCts$.
(vi) Let $(\tilde{L}, \Lambda)$ be a N_sSos in $\mathfrak{N}$. Since $\mathfrak{h}$ is $N_sScontraeCts$, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sSecs in $\mathfrak{N}$. Since every N_sSecs is a N_sSe^*cs, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sSe^*cs in $\mathfrak{N}$. Hence $\mathfrak{h}$ is a $N_sScontrae^*Cts$. ■

Example 2.2.

Let $\mathfrak{M} = \{\mathfrak{m}_1, \mathfrak{m}_2, \mathfrak{m}_3\} = \{\mathfrak{n}_1, \mathfrak{n}_2, \mathfrak{n}_3\} = \mathfrak{N}, \Lambda = \{q_1, q_2\}$ and N_sSs's $(\tilde{K}_1, \Lambda), (\tilde{K}_2, \Lambda), (\tilde{K}_3, \Lambda)$, $(\tilde{K}_4, \Lambda)$ & $((\tilde{K}_1 \cap \tilde{K}_2), \Lambda)$ in $\mathfrak{M}$ and $(\tilde{L}_1, \Lambda)$ in $\mathfrak{N}$ are defined as

$$(\tilde{K}_1, q_1) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.3}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.7}), (\frac{\mu_{\mathfrak{m}_2}}{0.5}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.5}), (\frac{\mu_{\mathfrak{m}_3}}{0.5}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.5})\rangle,$$
$$(\tilde{K}_1, q_2) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.4}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.6}), (\frac{\mu_{\mathfrak{m}_2}}{0.4}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.6}), (\frac{\mu_{\mathfrak{m}_3}}{0.5}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.5})\rangle,$$
$$(\tilde{K}_2, q_1) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.4}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.6}), (\frac{\mu_{\mathfrak{m}_2}}{0.2}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.8}), (\frac{\mu_{\mathfrak{m}_3}}{0.6}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.4})\rangle,$$

$$(\tilde{K}_2, q_2) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.6}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.4}), (\frac{\mu_{\mathfrak{m}_2}}{0.3}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.7}), (\frac{\mu_{\mathfrak{m}_3}}{0.4}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.6})\rangle,$$
$$(\tilde{K}_3, q_1) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.4}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.6}), (\frac{\mu_{\mathfrak{m}_2}}{0.5}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.5}), (\frac{\mu_{\mathfrak{m}_3}}{0.6}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.4})\rangle,$$
$$(\tilde{K}_3, q_2) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.6}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.4}), (\frac{\mu_{\mathfrak{m}_2}}{0.4}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.6}), (\frac{\mu_{\mathfrak{m}_3}}{0.5}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.5})\rangle,$$

$$(\tilde{K}_4, q_1) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.3}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.7}), (\frac{\mu_{\mathfrak{m}_2}}{0.5}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.5}), (\frac{\mu_{\mathfrak{m}_3}}{0.4}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.6})\rangle,$$
$$(\tilde{K}_4, q_2) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.4}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.6}), (\frac{\mu_{\mathfrak{m}_2}}{0.3}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.7}), (\frac{\mu_{\mathfrak{m}_3}}{0.6}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.4})\rangle,$$
$$(\tilde{K}_1 \cap \tilde{K}_2, q_1) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.3}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.7}), (\frac{\mu_{\mathfrak{m}_2}}{0.2}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.8}), (\frac{\mu_{\mathfrak{m}_3}}{0.5}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.5})\rangle,$$
$$(\tilde{K}_1 \cap \tilde{K}_2, q_2) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.4}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.6}), (\frac{\mu_{\mathfrak{m}_2}}{0.3}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.7}), (\frac{\mu_{\mathfrak{m}_3}}{0.4}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.6})\rangle,$$

$$(\tilde{L}_1, q_1) = \langle(\frac{\mu_{\mathfrak{n}_1}}{0.6}, \frac{\sigma_{\mathfrak{n}_1}}{0.5}, \frac{\nu_{\mathfrak{n}_1}}{0.4}), (\frac{\mu_{\mathfrak{n}_2}}{0.5}, \frac{\sigma_{\mathfrak{n}_2}}{0.5}, \frac{\nu_{\mathfrak{n}_2}}{0.5}), (\frac{\mu_{\mathfrak{n}_3}}{0.4}, \frac{\sigma_{\mathfrak{n}_3}}{0.5}, \frac{\nu_{\mathfrak{n}_3}}{0.6})\rangle,$$
$$(\tilde{L}_1, q_2) = \langle(\frac{\mu_{\mathfrak{n}_1}}{0.4}, \frac{\sigma_{\mathfrak{n}_1}}{0.5}, \frac{\nu_{\mathfrak{n}_1}}{0.6}), (\frac{\mu_{\mathfrak{n}_2}}{0.6}, \frac{\sigma_{\mathfrak{n}_2}}{0.5}, \frac{\nu_{\mathfrak{n}_2}}{0.4}), (\frac{\mu_{\mathfrak{n}_3}}{0.5}, \frac{\sigma_{\mathfrak{n}_3}}{0.5}, \frac{\nu_{\mathfrak{n}_3}}{0.5})\rangle.$$

Then, we have $\tau = \{0_{(\mathfrak{M},\Lambda)}, 1_{(\mathfrak{M},\Lambda)}, (\tilde{K}_1, \Lambda), (\tilde{K}_2, \Lambda), (\tilde{K}_3, \Lambda), (\tilde{K}_1 \cap \tilde{K}_2, \Lambda)\}$ and $\sigma = \{0_{(\mathfrak{N},\Lambda)}, 1_{(\mathfrak{N},\Lambda)}, (\tilde{L}_1, \Lambda)\}$. Consider an identity mapping $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \rightarrow (\mathfrak{N}, \sigma, \Lambda)$. Then, $\mathfrak{h}$ is $N_sScontraCts$ but not $N_sScontra\delta Cts$, because the set $\mathfrak{h}^{-1}(\tilde{L}_1, \Lambda) = (\tilde{K}_3, \Lambda)^c$ is a N_sScs but not $N_sS\delta cs$.

Example 2.3.

Let $\mathfrak{M} = \{\mathfrak{m}_1, \mathfrak{m}_2, \mathfrak{m}_3\} = \{\mathfrak{n}_1, \mathfrak{n}_2, \mathfrak{n}_3\} = \mathfrak{N}, \Lambda = \{q_1, q_2\}$ and N_sSs's $(\tilde{K}_1, \Lambda), (\tilde{K}_2, \Lambda), (\tilde{K}_3, \Lambda), (\tilde{K}_4, \Lambda)$ & $((\tilde{K}_1 \cap \tilde{K}_2), \Lambda)$ in $\mathfrak{M}$ and $(\tilde{L}_1, \Lambda)$ in $\mathfrak{N}$ are defined as

$$(\tilde{K}_1, q_1) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.3}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.7}), (\frac{\mu_{\mathfrak{m}_2}}{0.5}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.5}), (\frac{\mu_{\mathfrak{m}_3}}{0.5}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.5})\rangle,$$
$$(\tilde{K}_1, q_2) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.4}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.6}), (\frac{\mu_{\mathfrak{m}_2}}{0.4}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.6}), (\frac{\mu_{\mathfrak{m}_3}}{0.5}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.5})\rangle,$$
$$(\tilde{K}_2, q_1) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.4}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.6}), (\frac{\mu_{\mathfrak{m}_2}}{0.2}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.8}), (\frac{\mu_{\mathfrak{m}_3}}{0.6}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.4})\rangle,$$
$$(\tilde{K}_2, q_2) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.6}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.4}), (\frac{\mu_{\mathfrak{m}_2}}{0.3}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.7}), (\frac{\mu_{\mathfrak{m}_3}}{0.4}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.6})\rangle,$$
$$(\tilde{K}_3, q_1) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.4}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.6}), (\frac{\mu_{\mathfrak{m}_2}}{0.5}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.5}), (\frac{\mu_{\mathfrak{m}_3}}{0.6}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.4})\rangle,$$
$$(\tilde{K}_3, q_2) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.6}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.4}), (\frac{\mu_{\mathfrak{m}_2}}{0.4}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.6}), (\frac{\mu_{\mathfrak{m}_3}}{0.5}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.5})\rangle,$$
$$(\tilde{K}_4, q_1) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.3}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.7}), (\frac{\mu_{\mathfrak{m}_2}}{0.5}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.5}), (\frac{\mu_{\mathfrak{m}_3}}{0.4}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.6})\rangle,$$
$$(\tilde{K}_4, q_2) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.4}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.6}), (\frac{\mu_{\mathfrak{m}_2}}{0.3}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.7}), (\frac{\mu_{\mathfrak{m}_3}}{0.6}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.4})\rangle,$$
$$(\tilde{K}_1 \cap \tilde{K}_2, q_1) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.3}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.7}), (\frac{\mu_{\mathfrak{m}_2}}{0.2}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.8}), (\frac{\mu_{\mathfrak{m}_3}}{0.5}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.5})\rangle,$$
$$(\tilde{K}_1 \cap \tilde{K}_2, q_2) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.4}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.6}), (\frac{\mu_{\mathfrak{m}_2}}{0.3}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.7}), (\frac{\mu_{\mathfrak{m}_3}}{0.4}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.6})\rangle,$$
$$(\tilde{L}_1, q_1) = \langle(\frac{\mu_{\mathfrak{n}_1}}{0.7}, \frac{\sigma_{\mathfrak{n}_1}}{0.5}, \frac{\nu_{\mathfrak{n}_1}}{0.3}), (\frac{\mu_{\mathfrak{n}_2}}{0.5}, \frac{\sigma_{\mathfrak{n}_2}}{0.5}, \frac{\nu_{\mathfrak{n}_2}}{0.5}), (\frac{\mu_{\mathfrak{n}_3}}{0.6}, \frac{\sigma_{\mathfrak{n}_3}}{0.5}, \frac{\nu_{\mathfrak{n}_3}}{0.4})\rangle,$$
$$(\tilde{L}_1, q_2) = \langle(\frac{\mu_{\mathfrak{n}_1}}{0.6}, \frac{\sigma_{\mathfrak{n}_1}}{0.5}, \frac{\nu_{\mathfrak{n}_1}}{0.4}), (\frac{\mu_{\mathfrak{n}_2}}{0.7}, \frac{\sigma_{\mathfrak{n}_2}}{0.5}, \frac{\nu_{\mathfrak{n}_2}}{0.3}), (\frac{\mu_{\mathfrak{n}_3}}{0.4}, \frac{\sigma_{\mathfrak{n}_3}}{0.5}, \frac{\nu_{\mathfrak{n}_3}}{0.6})\rangle.$$

Then, we have $\tau = \{0_{(\mathfrak{M},\Lambda)}, 1_{(\mathfrak{M},\Lambda)}, (\tilde{K}_1, \Lambda), (\tilde{K}_2, \Lambda), (\tilde{K}_3, \Lambda), (\tilde{K}_1 \cap \tilde{K}_2, \Lambda)\}$ and $\sigma = \{0_{(\mathfrak{N},\Lambda)}, 1_{(\mathfrak{N},\Lambda)}, (\tilde{L}_1, \Lambda)\}$. Consider an identity mapping $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \rightarrow (\mathfrak{N}, \sigma, \Lambda)$. Then, (i) $\mathfrak{h}$ is $N_sScontra\delta\mathcal{P}Cts$ but not $N_sScontraCts$, because the set $\mathfrak{h}^{-1}(\tilde{L}_1, \Lambda) = (\tilde{K}_4, \Lambda)^c$ is a $N_sS\delta\mathcal{P}cs$ but not N_sScs, (ii) $\mathfrak{h}$ is $N_sScontraeCts$ but not $N_sScontra\delta\mathcal{S}Cts$, because the set $\mathfrak{h}^{-1}(\tilde{L}_1, \Lambda) = (\tilde{K}_4, \Lambda)^c$ is a N_sSecs but not $N_sS\delta\mathcal{S}cs$.

Example 2.4.

Let $\mathfrak{M} = \{\mathfrak{m}_1, \mathfrak{m}_2, \mathfrak{m}_3\} = \{\mathfrak{n}_1, \mathfrak{n}_2, \mathfrak{n}_3\} = \mathfrak{N}, \Lambda = \{q_1, q_2\}$ and N_sSs's $(\tilde{K}_1, \Lambda), (\tilde{K}_2, \Lambda)$ & $(\tilde{K}_3, \Lambda)$ in $\mathfrak{M}$ and $(\tilde{L}_1, \Lambda)$ in $\mathfrak{N}$ are defined as

$$(\tilde{K}_1, q_1) = \langle (\frac{\mu_{\mathfrak{m}_1}}{0.2}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.8}), (\frac{\mu_{\mathfrak{m}_2}}{0.3}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.7}), (\frac{\mu_{\mathfrak{m}_3}}{0.4}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.6}) \rangle,$$
$$(\tilde{K}_1, q_2) = \langle (\frac{\mu_{\mathfrak{m}_1}}{0.3}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.7}), (\frac{\mu_{\mathfrak{m}_2}}{0.2}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.7}), (\frac{\mu_{\mathfrak{m}_3}}{0.4}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.7}) \rangle,$$
$$(\tilde{K}_2, q_1) = \langle (\frac{\mu_{\mathfrak{m}_1}}{0.1}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.9}), (\frac{\mu_{\mathfrak{m}_2}}{0.1}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.9}), (\frac{\mu_{\mathfrak{m}_3}}{0.4}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.6}) \rangle,$$
$$(\tilde{K}_2, q_2) = \langle (\frac{\mu_{\mathfrak{m}_1}}{0.2}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.8}), (\frac{\mu_{\mathfrak{m}_2}}{0.1}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.8}), (\frac{\mu_{\mathfrak{m}_3}}{0.3}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.7}) \rangle,$$
$$(\tilde{K}_3, q_1) = \langle (\frac{\mu_{\mathfrak{m}_1}}{0.2}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.8}), (\frac{\mu_{\mathfrak{m}_2}}{0.4}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.6}), (\frac{\mu_{\mathfrak{m}_3}}{0.4}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.6}) \rangle,$$
$$(\tilde{K}_3, q_2) = \langle (\frac{\mu_{\mathfrak{m}_1}}{0.3}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.6}), (\frac{\mu_{\mathfrak{m}_2}}{0.3}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.6}), (\frac{\mu_{\mathfrak{m}_3}}{0.5}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.6}) \rangle,$$
$$(\tilde{L}_1, q_1) = \langle (\frac{\mu_{\mathfrak{n}_1}}{0.8}, \frac{\sigma_{\mathfrak{n}_1}}{0.5}, \frac{\nu_{\mathfrak{n}_1}}{0.2}), (\frac{\mu_{\mathfrak{n}_2}}{0.6}, \frac{\sigma_{\mathfrak{n}_2}}{0.5}, \frac{\nu_{\mathfrak{n}_2}}{0.4}), (\frac{\mu_{\mathfrak{n}_3}}{0.6}, \frac{\sigma_{\mathfrak{n}_3}}{0.5}, \frac{\nu_{\mathfrak{n}_3}}{0.4}) \rangle,$$
$$(\tilde{L}_1, q_2) = \langle (\frac{\mu_{\mathfrak{n}_1}}{0.6}, \frac{\sigma_{\mathfrak{n}_1}}{0.5}, \frac{\nu_{\mathfrak{n}_1}}{0.3}), (\frac{\mu_{\mathfrak{n}_2}}{0.6}, \frac{\sigma_{\mathfrak{n}_2}}{0.5}, \frac{\nu_{\mathfrak{n}_2}}{0.3}), (\frac{\mu_{\mathfrak{n}_3}}{0.6}, \frac{\sigma_{\mathfrak{n}_3}}{0.5}, \frac{\nu_{\mathfrak{n}_3}}{0.5}) \rangle.$$

Then, we have $\tau = \{0_{(\mathfrak{M},\Lambda)}, 1_{(\mathfrak{M},\Lambda)}, (\tilde{K}_1, \Lambda), (\tilde{K}_2, \Lambda)\}$ and $\sigma = \{0_{(\mathfrak{N},\Lambda)}, 1_{(\mathfrak{N},\Lambda)}, (\tilde{L}_1, \Lambda)\}$. Consider an identity mapping $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \to (\mathfrak{N}, \sigma, \Lambda)$. Then, $\mathfrak{h}$ is $N_sScontraeCts$ (respectively, $N_sScontra\delta\mathcal{S}Cts$) but not $N_sScontra\delta\mathcal{P}Cts$ (respectively, $N_sScontraCts$), because the set $\mathfrak{h}^{-1}(\tilde{L}_1, \Lambda) = (\tilde{K}_3, \Lambda)^c$ is a N_sSecs (respectively, $N_sS\delta\mathcal{S}cs$) but not $N_sS\delta\mathcal{P}cs$ (respectively, N_sScs).

Example 2.5.

Let $\mathfrak{M} = \{\mathfrak{m}_1, \mathfrak{m}_2, \mathfrak{m}_3\} = \{\mathfrak{n}_1, \mathfrak{n}_2, \mathfrak{n}_3\} = \mathfrak{N}, \Lambda = \{q_1, q_2\}$ and N_sSs's $(\tilde{K}_1, \Lambda), (\tilde{K}_2, \Lambda), (\tilde{K}_3, \Lambda)$, $(\tilde{K}_4, \Lambda)$ & $(\tilde{K}_5, \Lambda)$ in $\mathfrak{M}$ and $(\tilde{L}_1, \Lambda)$ in $\mathfrak{N}$ are defined as

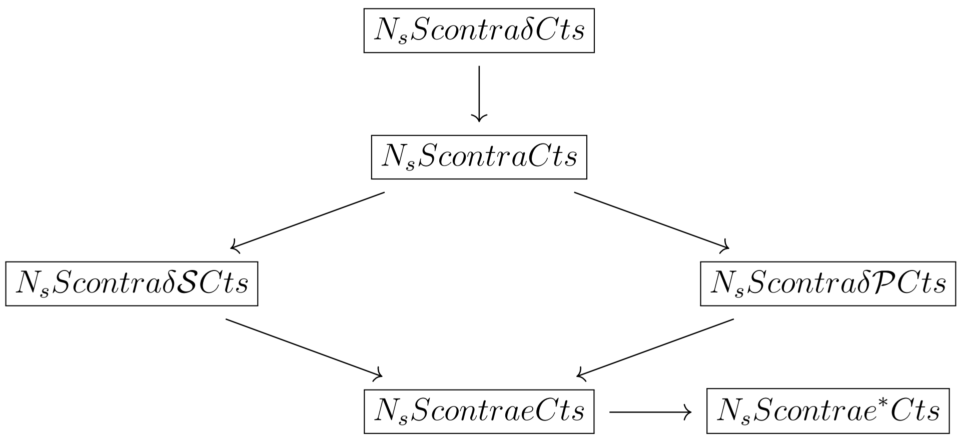
$$(\tilde{K}_1, q_1) = \langle (\frac{\mu_{\mathfrak{m}_1}}{1}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0}), (\frac{\mu_{\mathfrak{m}_2}}{0}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0}), (\frac{\mu_{\mathfrak{m}_3}}{0.2}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.7}) \rangle,$$
$$(\tilde{K}_1, q_2) = \langle (\frac{\mu_{\mathfrak{m}_1}}{0.9}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.1}), (\frac{\mu_{\mathfrak{m}_2}}{0.9}, \frac{\sigma_{\mathfrak{m}_2}}{0.6}, \frac{\nu_{\mathfrak{m}_2}}{0.2}), (\frac{\mu_{\mathfrak{m}_3}}{0.3}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.8}) \rangle,$$
$$(\tilde{K}_2, q_1) = \langle (\frac{\mu_{\mathfrak{m}_1}}{0}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{1}), (\frac{\mu_{\mathfrak{m}_2}}{1}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0}), (\frac{\mu_{\mathfrak{m}_3}}{0}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{1}) \rangle,$$
$$(\tilde{K}_2, q_2) = \langle (\frac{\mu_{\mathfrak{m}_1}}{0.1}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.8}), (\frac{\mu_{\mathfrak{m}_2}}{0.1}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.4}), (\frac{\mu_{\mathfrak{m}_3}}{0}, \frac{\sigma_{\mathfrak{m}_3}}{0.4}, \frac{\nu_{\mathfrak{m}_3}}{0.9}) \rangle,$$
$$(\tilde{K}_3, q_1) = \langle (\frac{\mu_{\mathfrak{m}_1}}{0}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{1}), (\frac{\mu_{\mathfrak{m}_2}}{0}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0}), (\frac{\mu_{\mathfrak{m}_3}}{0}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{1}) \rangle,$$
$$(\tilde{K}_3, q_2) = \langle (\frac{\mu_{\mathfrak{m}_1}}{0.1}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.8}), (\frac{\mu_{\mathfrak{m}_2}}{0.1}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.4}), (\frac{\mu_{\mathfrak{m}_3}}{0}, \frac{\sigma_{\mathfrak{m}_3}}{0.4}, \frac{\nu_{\mathfrak{m}_3}}{0.9}) \rangle,$$
$$(\tilde{K}_4, q_1) = \langle (\frac{\mu_{\mathfrak{m}_1}}{1}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0}), (\frac{\mu_{\mathfrak{m}_2}}{1}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0}), (\frac{\mu_{\mathfrak{m}_3}}{0.2}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.7}) \rangle,$$
$$(\tilde{K}_4, q_2) = \langle (\frac{\mu_{\mathfrak{m}_1}}{0.9}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.1}), (\frac{\mu_{\mathfrak{m}_2}}{0.9}, \frac{\sigma_{\mathfrak{m}_2}}{0.6}, \frac{\nu_{\mathfrak{m}_2}}{0.2}), (\frac{\mu_{\mathfrak{m}_3}}{0.3}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.8}) \rangle,$$
$$(\tilde{K}_5, q_1) = \langle (\frac{\mu_{\mathfrak{m}_1}}{1}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0}), (\frac{\mu_{\mathfrak{m}_2}}{0}, \frac{\sigma_{\mathfrak{m}_2}}{0.5}, \frac{\nu_{\mathfrak{m}_2}}{0.2}), (\frac{\mu_{\mathfrak{m}_3}}{0}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0}) \rangle,$$

$$(\tilde{K}_5, q_2) = \langle(\frac{\mu_{\mathfrak{m}_1}}{0.8}, \frac{\sigma_{\mathfrak{m}_1}}{0.5}, \frac{\nu_{\mathfrak{m}_1}}{0.2}), (\frac{\mu_{\mathfrak{m}_2}}{0.2}, \frac{\sigma_{\mathfrak{m}_2}}{0.4}, \frac{\nu_{\mathfrak{m}_2}}{0.3}), (\frac{\mu_{\mathfrak{m}_3}}{0.3}, \frac{\sigma_{\mathfrak{m}_3}}{0.5}, \frac{\nu_{\mathfrak{m}_3}}{0.1})\rangle,$$
$$(\tilde{L}_1, q_1) = \langle(\frac{\mu_{\mathfrak{n}_1}}{0}, \frac{\sigma_{\mathfrak{n}_1}}{0.5}, \frac{\nu_{\mathfrak{n}_1}}{1}), (\frac{\mu_{\mathfrak{n}_2}}{0.2}, \frac{\sigma_{\mathfrak{n}_2}}{0.5}, \frac{\nu_{\mathfrak{n}_2}}{0}), (\frac{\mu_{\mathfrak{n}_3}}{0}, \frac{\sigma_{\mathfrak{n}_3}}{0.5}, \frac{\nu_{\mathfrak{n}_3}}{0})\rangle,$$
$$(\tilde{L}_1, q_2) = \langle(\frac{\mu_{\mathfrak{n}_1}}{0.2}, \frac{\sigma_{\mathfrak{n}_1}}{0.5}, \frac{\nu_{\mathfrak{n}_1}}{0.8}), (\frac{\mu_{\mathfrak{n}_2}}{0.3}, \frac{\sigma_{\mathfrak{n}_2}}{0.4}, \frac{\nu_{\mathfrak{n}_2}}{0.2}), (\frac{\mu_{\mathfrak{n}_3}}{0.1}, \frac{\sigma_{\mathfrak{n}_3}}{0.5}, \frac{\nu_{\mathfrak{n}_3}}{0.3})\rangle.$$

Then, we have $\tau = \{0_{(\mathfrak{M},\Lambda)}, 1_{(\mathfrak{M},\Lambda)}, (\tilde{K}_1, \Lambda), (\tilde{K}_2, \Lambda), (\tilde{K}_3, \Lambda), (\tilde{K}_4, \Lambda)\}$ and $\sigma = \{0_{(\mathfrak{N},\Lambda)}, 1_{(\mathfrak{N},\Lambda)}, (\tilde{L}_1, \Lambda)\}$. Consider an identity mapping $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \to (\mathfrak{N}, \sigma, \Lambda)$. Then, $\mathfrak{h}$ is $N_sScontrae^*Cts$ but not $N_sScontraeCts$, because the set $\mathfrak{h}^{-1}(\tilde{L}_1, \Lambda) = (\tilde{K}_5, \Lambda)^c$ is a N_sSe^*cs but not N_sSecs.

Remark 2.1.

From the results discussed above, the following diagram is obtained.



Theorem 2.1.

A map $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \to (\mathfrak{N}, \sigma, \Lambda)$ is $N_sScontraeCts$ if and only if the inverse image of every N_sScs in $\mathfrak{N}$ is N_sSeos in $\mathfrak{M}$.

Proof:

Let $(\tilde{L}, \Lambda)$ be a N_sScs in $\mathfrak{N}$. This implies $(\tilde{L}, \Lambda)^c$ is N_sSos in $\mathfrak{N}$. Since $\mathfrak{h}$ is $N_sScontraeCts$, $\mathfrak{h}^{-1}((\tilde{L}, \Lambda)^c)$ is N_sSecs in $\mathfrak{M}$. Since $\mathfrak{h}^{-1}((\tilde{L}, \Lambda)^c) = (\mathfrak{h}^{-1}(\tilde{L}, \Lambda))^c$, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sSeos in $\mathfrak{M}$. Conversely, let $(\tilde{L}, \Lambda)$ be a N_sScs in $\mathfrak{N}$. Then $(\tilde{L}, \Lambda)^c$ is a N_sSos in $\mathfrak{N}$. By hypothesis $\mathfrak{h}^{-1}((\tilde{L}, \Lambda)^c)$ is N_sSecs in $\mathfrak{M}$. Since $\mathfrak{h}^{-1}((\tilde{L}, \Lambda)^c) = (\mathfrak{h}^{-1}(\tilde{L}, \Lambda))^c$, $\Big(\mathfrak{h}^{-1}(\tilde{L}, \Lambda)\Big)^c$ is a N_sSecs in $\mathfrak{M}$. Therefore, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sSeos in $\mathfrak{M}$. Hence, $\mathfrak{h}$ is $N_sScontraeCts$. ■

Theorem 2.2.

Let $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \to (\mathfrak{N}, \sigma, \Lambda)$ be $N_sScontraeCts$. Then, $\mathfrak{h}$ is a $N_sScontraCts$ if $\mathfrak{M}$ is a $N_sSeU_{\frac{1}{2}}$-space.

Proof:

Let $(\tilde{L}, \Lambda)$ be a N_sSos in $\mathfrak{N}$. Then, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sSecs in $\mathfrak{M}$, by hypothesis. As $\mathfrak{M}$ is a $N_sSeU_{\frac{1}{2}}$-space, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sScs in $\mathfrak{M}$. Hence, $\mathfrak{h}$ is a $N_sScontraCts$. ■

Theorem 2.3.

Let $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \to (\mathfrak{N}, \sigma, \Lambda)$ be a $N_sScontraeCts$ map and $\mathfrak{g} : (\mathfrak{N}, \sigma, \Lambda) \to (P, \rho, \Lambda)$ be a N_sSCts, then $\mathfrak{g} \circ \mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \to (P, \rho, \Lambda)$ is a $N_sScontraeCts$.

Proof:

Let $(\tilde{A}, \Lambda)$ be a N_sSos in P. Then, $\mathfrak{g}^{-1}(\tilde{A}, \Lambda)$ is a N_sSos in $\mathfrak{N}$, by hypothesis. Since $\mathfrak{h}$ is a $N_sScontraeCts$ map, $\mathfrak{h}^{-1}\left(\mathfrak{g}^{-1}(\tilde{A}, \Lambda)\right)$ is a N_sSecs in $\mathfrak{M}$. Hence, $\mathfrak{g} \circ \mathfrak{h}$ is a $N_sScontraeCts$ map. ■

Theorem 2.4.

Let $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \to (\mathfrak{N}, \sigma, \Lambda)$ be a $N_sScontraeCts$ map. Then, the following conditions hold.
(i) $\mathfrak{h}(N_sSecl(\tilde{K}, \Lambda)) \supseteq N_sSint(\mathfrak{h}(\tilde{K}, \Lambda))$, for all $(\tilde{K}, \Lambda)$ in $\mathfrak{M}$.
(ii) $N_sSecl(\mathfrak{h}^{-1}(\tilde{L}, \Lambda)) \supseteq \mathfrak{h}^{-1}(N_sSint(\tilde{L}, \Lambda))$, for all $(\tilde{L}, \Lambda)$ in $\mathfrak{N}$.

Proof:

(i) As $N_sSecl(\mathfrak{h}(\tilde{K}, \Lambda))$ is a N_sSecs in $\mathfrak{N}$ and $\mathfrak{h}$ is $N_sSecontraCts$, $\mathfrak{h}^{-1}(N_sSecl(\mathfrak{h}(\tilde{K}, \Lambda)))$ is N_sSeos in $\mathfrak{M}$. Now, as $(\tilde{K}, \Lambda) \supseteq \mathfrak{h}^{-1}(N_sSint(\mathfrak{h}(\tilde{K}, \Lambda)))$, $N_sSecl(\tilde{K}, \Lambda) \supseteq \mathfrak{h}^{-1}(N_sSint(\mathfrak{h}(\tilde{K}, \Lambda)))$. Therefore, $\mathfrak{h}(N_sSecl(\tilde{K}, \Lambda)) \supseteq N_sSint(\mathfrak{h}(\tilde{K}, \Lambda))$.

(ii) By replacing $(\tilde{K}, \Lambda)$ with $(\tilde{L}, \Lambda)$ in (i), we get $\mathfrak{h}(N_sSecl(\mathfrak{h}^{-1}(\tilde{L}, \Lambda))) \supseteq N_sSint (\mathfrak{h}(\mathfrak{h}^{-1}(\tilde{L}, \Lambda))) \supseteq N_sSint(\tilde{L}, \Lambda)$. Hence, $N_sSecl(\mathfrak{h}^{-1}(\tilde{L}, \Lambda)) \supseteq \mathfrak{h}^{-1}(N_sSint(\tilde{L}, \Lambda))$. ■

3. Neutrosophic soft contra e-irresolute maps in N_sSts

The neutrosophic soft contra e-irresolute maps are introduced and some of its properties are dicussed in this section.

Definition 3.1.

A map $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \to (\mathfrak{N}, \sigma, \Lambda)$ is known as a N_sS contra e-irresolute (in short, $N_sScontraeIrr$) map if $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sSecs in $(\mathfrak{M}, \tau, \Lambda)$ for every N_sSeos $(\tilde{L}, \Lambda)$ of $(\mathfrak{N}, \sigma, \Lambda)$.

Theorem 3.1.

Let $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \to (\mathfrak{N}, \sigma, \Lambda)$ be a $N_sScontraeIrr$ map. Then, $\mathfrak{h}$ is $N_sScontraeCts$. But the converse need not be true.

Proof:

Let $\mathfrak{h}$ be a $N_sScontraeIrr$ map. Let $(\tilde{L},\Lambda)$ be any N_sSos in $\mathfrak{N}$. Since every N_sSos is a N_sSeos, $(\tilde{L},\Lambda)$ is a N_sSeos in $\mathfrak{N}$. Since $\mathfrak{h}$ is $N_sScontraeIrr$ map, $\mathfrak{h}^{-1}(\tilde{L},\Lambda)$ is a N_sSecs in $\mathfrak{M}$. Therefore, $\mathfrak{h}$ is a $N_sScontraeCts$ map. ■

Example 3.1.

Let $\mathfrak{M} = \{\mathfrak{m}_1,\mathfrak{m}_2,\mathfrak{m}_3\} = \{\mathfrak{n}_1,\mathfrak{n}_2,\mathfrak{n}_3\} = \mathfrak{N}, \Lambda = \{q_1,q_2\}$ and N_sSs's $(\tilde{K}_1,\Lambda),(\tilde{K}_2,\Lambda)$ and $(\tilde{K}_3,\Lambda)$ in $\mathfrak{M}$ and $(\tilde{L}_1,\Lambda)$ and $(\tilde{L}_2,\Lambda)$ in $\mathfrak{N}$ are defined as

$$
\begin{aligned}
(\tilde{K}_1,q_1) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0.2},\frac{\sigma_{\mathfrak{m}_1}}{0.5},\frac{\nu_{\mathfrak{m}_1}}{0.8}),(\frac{\mu_{\mathfrak{m}_2}}{0.3},\frac{\sigma_{\mathfrak{m}_2}}{0.5},\frac{\nu_{\mathfrak{m}_2}}{0.7}),(\frac{\mu_{\mathfrak{m}_3}}{0.4},\frac{\sigma_{\mathfrak{m}_3}}{0.5},\frac{\nu_{\mathfrak{m}_3}}{0.6})\rangle,\\
(\tilde{K}_1,q_2) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0.3},\frac{\sigma_{\mathfrak{m}_1}}{0.5},\frac{\nu_{\mathfrak{m}_1}}{0.7}),(\frac{\mu_{\mathfrak{m}_2}}{0.4},\frac{\sigma_{\mathfrak{m}_2}}{0.5},\frac{\nu_{\mathfrak{m}_2}}{0.6}),(\frac{\mu_{\mathfrak{m}_3}}{0.5},\frac{\sigma_{\mathfrak{m}_3}}{0.5},\frac{\nu_{\mathfrak{m}_3}}{0.5})\rangle,\\
(\tilde{K}_2,q_1) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0.1},\frac{\sigma_{\mathfrak{m}_1}}{0.5},\frac{\nu_{\mathfrak{m}_1}}{0.9}),(\frac{\mu_{\mathfrak{m}_2}}{0.1},\frac{\sigma_{\mathfrak{m}_2}}{0.5},\frac{\nu_{\mathfrak{m}_2}}{0.9}),(\frac{\mu_{\mathfrak{m}_3}}{0.4},\frac{\sigma_{\mathfrak{m}_3}}{0.5},\frac{\nu_{\mathfrak{m}_3}}{0.6})\rangle,\\
(\tilde{K}_2,q_2) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0.2},\frac{\sigma_{\mathfrak{m}_1}}{0.5},\frac{\nu_{\mathfrak{m}_1}}{0.8}),(\frac{\mu_{\mathfrak{m}_2}}{0.3},\frac{\sigma_{\mathfrak{m}_2}}{0.5},\frac{\nu_{\mathfrak{m}_2}}{0.7}),(\frac{\mu_{\mathfrak{m}_3}}{0.3},\frac{\sigma_{\mathfrak{m}_3}}{0.5},\frac{\nu_{\mathfrak{m}_3}}{0.7})\rangle,\\
(\tilde{K}_3,q_1) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0.2},\frac{\sigma_{\mathfrak{m}_1}}{0.5},\frac{\nu_{\mathfrak{m}_1}}{0.8}),(\frac{\mu_{\mathfrak{m}_2}}{0.4},\frac{\sigma_{\mathfrak{m}_2}}{0.5},\frac{\nu_{\mathfrak{m}_2}}{0.6}),(\frac{\mu_{\mathfrak{m}_3}}{0.4},\frac{\sigma_{\mathfrak{m}_3}}{0.5},\frac{\nu_{\mathfrak{m}_3}}{0.6})\rangle,\\
(\tilde{K}_3,q_2) &= \langle(\frac{\mu_{\mathfrak{m}_1}}{0.3},\frac{\sigma_{\mathfrak{m}_1}}{0.5},\frac{\nu_{\mathfrak{m}_1}}{0.7}),(\frac{\mu_{\mathfrak{m}_2}}{0.5},\frac{\sigma_{\mathfrak{m}_2}}{0.5},\frac{\nu_{\mathfrak{m}_2}}{0.5}),(\frac{\mu_{\mathfrak{m}_3}}{0.5},\frac{\sigma_{\mathfrak{m}_3}}{0.5},\frac{\nu_{\mathfrak{m}_3}}{0.5})\rangle,\\
(\tilde{L}_1,q_1) &= \langle(\frac{\mu_{\mathfrak{n}_1}}{0.9},\frac{\sigma_{\mathfrak{n}_1}}{0.5},\frac{\nu_{\mathfrak{n}_1}}{0.1}),(\frac{\mu_{\mathfrak{n}_2}}{0.9},\frac{\sigma_{\mathfrak{n}_2}}{0.5},\frac{\nu_{\mathfrak{n}_2}}{0.1}),(\frac{\mu_{\mathfrak{n}_3}}{0.6},\frac{\sigma_{\mathfrak{n}_3}}{0.5},\frac{\nu_{\mathfrak{n}_3}}{0.4})\rangle,\\
(\tilde{L}_1,q_2) &= \langle(\frac{\mu_{\mathfrak{n}_1}}{0.8},\frac{\sigma_{\mathfrak{n}_1}}{0.5},\frac{\nu_{\mathfrak{n}_1}}{0.2}),(\frac{\mu_{\mathfrak{n}_2}}{0.7},\frac{\sigma_{\mathfrak{n}_2}}{0.5},\frac{\nu_{\mathfrak{n}_2}}{0.3}),(\frac{\mu_{\mathfrak{n}_3}}{0.7},\frac{\sigma_{\mathfrak{n}_3}}{0.5},\frac{\nu_{\mathfrak{n}_3}}{0.3})\rangle,\\
(\tilde{L}_2,q_1) &= \langle(\frac{\mu_{\mathfrak{n}_1}}{0.9},\frac{\sigma_{\mathfrak{n}_1}}{0.5},\frac{\nu_{\mathfrak{n}_1}}{0.1}),(\frac{\mu_{\mathfrak{n}_2}}{0.6},\frac{\sigma_{\mathfrak{n}_2}}{0.5},\frac{\nu_{\mathfrak{n}_2}}{0.4}),(\frac{\mu_{\mathfrak{n}_3}}{0.5},\frac{\sigma_{\mathfrak{n}_3}}{0.5},\frac{\nu_{\mathfrak{n}_3}}{0.5})\rangle,\\
(\tilde{L}_2,q_2) &= \langle(\frac{\mu_{\mathfrak{n}_1}}{0.8},\frac{\sigma_{\mathfrak{n}_1}}{0.5},\frac{\nu_{\mathfrak{n}_1}}{0.2}),(\frac{\mu_{\mathfrak{n}_2}}{0.4},\frac{\sigma_{\mathfrak{n}_2}}{0.5},\frac{\nu_{\mathfrak{n}_2}}{0.6}),(\frac{\mu_{\mathfrak{n}_3}}{0.4},\frac{\sigma_{\mathfrak{n}_3}}{0.5},\frac{\nu_{\mathfrak{n}_3}}{0.6})\rangle.
\end{aligned}
$$

Then, we have $\tau = \{0_{(\mathfrak{M},\Lambda)},1_{(\mathfrak{M},\Lambda)},(\tilde{K}_1,\Lambda),(\tilde{K}_2,\Lambda)\}$ and $\sigma = \{0_{(\mathfrak{N},\Lambda)},1_{(\mathfrak{N},\Lambda)},(\tilde{L}_1,\Lambda)\}$. Consider an identity mapping $\mathfrak{h}:(\mathfrak{M},\tau,\Lambda)\to(\mathfrak{N},\sigma,\Lambda)$. Then, $\mathfrak{h}$ is $N_sScontraeCts$ but not $N_sScontraeIrr$, because the set $(\tilde{L}_2,\Lambda)$ is a N_sSecs in $\mathfrak{N}$ but $\mathfrak{h}^{-1}(\tilde{L}_2,\Lambda)$ is not N_sSecs in $\mathfrak{M}$.

Theorem 3.2.

Let $\mathfrak{h}:(\mathfrak{M},\tau,\Lambda)\to(\mathfrak{N},\sigma,\Lambda)$ be a $N_sScontraeIrr$. Then, $\mathfrak{h}$ is a $N_sScontraCts$ map if $\mathfrak{M}$ is a $N_sSeU_{\frac{1}{2}}$-space.

Proof:

Let $(\tilde{L},\Lambda)$ be a N_sSos in $\mathfrak{N}$. Then, $(\tilde{L},\Lambda)$ is a N_sSeos in $\mathfrak{N}$. Hence, $\mathfrak{h}^{-1}(\tilde{L},\Lambda)$ is a N_sSecs in $\mathfrak{M}$. Since $\mathfrak{M}$ is a $N_sSeU_{\frac{1}{2}}$-space, $\mathfrak{h}^{-1}(\tilde{L},\Lambda)$ is a N_sScs in $\mathfrak{M}$. Therefore, $\mathfrak{h}$ is a $N_sScontraCts$ map. ■

Theorem 3.3.

Let $\mathfrak{h}:(\mathfrak{M},\tau,\Lambda)\to(\mathfrak{N},\sigma,\Lambda)$ be a $N_sScontraeIrr$ map and $\mathfrak{g}:(\mathfrak{N},\sigma,\Lambda)\to(P,\rho,\Lambda)$ be N_sSeCts map. Then, $\mathfrak{g}\circ\mathfrak{h}:(\mathfrak{M},\tau,\Lambda)\to(P,\rho,\Lambda)$ is a $N_sScontraeCts$ map.

Proof:

Consider a N_sSos $(\tilde{A}, \Lambda)$ in P. Since $\mathfrak{g}$ is N_sSeCts, $\mathfrak{g}^{-1}(\tilde{A}, \Lambda)$ is a N_sSeos in $\mathfrak{N}$. As $\mathfrak{h}$ is $N_sScontraeIrr$, $\mathfrak{h}^{-1}(\mathfrak{g}^{-1}(\tilde{A}, \Lambda))$ is a N_sSecs in $\mathfrak{M}$. Therefore, $\mathfrak{g} \circ \mathfrak{h}$ is a $N_sScontraeCts$ map. ■

Theorem 3.4.

Let $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \rightarrow (\mathfrak{N}, \sigma, \Lambda)$ and $\mathfrak{g} : (\mathfrak{N}, \sigma, \Lambda) \rightarrow (P, \rho, \Lambda)$ be mappings. Then, $\mathfrak{g} \circ \mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \rightarrow (P, \rho, \Lambda)$ is: (i) $N_sScontraeCts$ if $\mathfrak{h}$ is N_sSeIrr and $\mathfrak{g}$ is $N_sScontraeCts$. (ii) $N_sScontraeIrr$ if $\mathfrak{h}$ is $N_sScontraeIrr$ (respectively, $eIrr$) and $\mathfrak{g}$ is N_sSeIrr (respectively, $contraeIrr$).

Proof:

(i) Consider a N_sSos $(\tilde{A}, \Lambda)$ in P. Since $\mathfrak{g}$ is $N_sScontraeCts$, $\mathfrak{g}^{-1}(\tilde{A}, \Lambda)$ is a N_sSecs in $\mathfrak{N}$. As $\mathfrak{h}$ is N_sSeIrr, $\mathfrak{h}^{-1}(\mathfrak{g}^{-1}(\tilde{A}, \Lambda))$ is a N_sSecs in $\mathfrak{M}$. Therefore, $\mathfrak{g} \circ \mathfrak{h}$ is a $N_sScontraeCts$ map.
(ii) Consider a N_sSeos $(\tilde{A}, \Lambda)$ in P. Since $\mathfrak{g}$ is N_sSeIrr, $\mathfrak{g}^{-1}(\tilde{A}, \Lambda)$ is a N_sSeos in $\mathfrak{N}$. As $\mathfrak{h}$ is $N_sScontraeIrr$, $\mathfrak{h}^{-1}(\mathfrak{g}^{-1}(\tilde{A}, \Lambda))$ is a N_sSecs in $\mathfrak{M}$. Therefore, $\mathfrak{g} \circ \mathfrak{h}$ is a $N_sScontraeIrr$ map.
The other case is similar. ■

Theorem 3.5.

Consider a map $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \rightarrow (\mathfrak{N}, \sigma, \Lambda)$.
(i) If $(\mathfrak{M}, \tau, \Lambda)$ is $N_sSeU_{\frac{1}{2}}$-space, then the concepts of $N_sScontraCts$ and $N_sScontraeCts$ are equivalent.
(ii) If $(\mathfrak{N}, \sigma, \Lambda)$ is $N_sSeU_{\frac{1}{2}}$-space, then the concepts of $N_sScontraeCts$ and $N_sScontraeIrr$ are equivalent.
(iii) If $(\mathfrak{M}, \tau, \Lambda)$ and $(\mathfrak{N}, \sigma, \Lambda)$ are $N_sSeU_{\frac{1}{2}}$-spaces, then the concepts of $N_sScontraCts$, $N_sScontraeCts$ and $N_sScontraeIrr$ are equivalent.

Proof:

(i) Let $(\tilde{L}, \Lambda)$ be any N_sSos in $\mathfrak{N}$. Let $\mathfrak{h}$ be $N_sScontraeCts$. Then, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sSecs in $\mathfrak{M}$. As $(\mathfrak{M}, \tau, \Lambda)$ is $N_sSeU_{\frac{1}{2}}$-space, $(\tilde{L}, \Lambda)$ is a N_sScs in $\mathfrak{M}$. Hence, $\mathfrak{h}$ is $N_sScontraCts$.
(ii) Let $(\tilde{L}, \Lambda)$ be a N_sSeos in $\mathfrak{N}$. As $(\mathfrak{N}, \sigma, \Lambda)$ is $N_sSeU_{\frac{1}{2}}$-space, $(\tilde{L}, \Lambda)$ is a N_sSos in $\mathfrak{N}$. Let $\mathfrak{h}$ be $N_sScontraeCts$. Then, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sSecs in $\mathfrak{M}$. Hence, $\mathfrak{h}$ is $N_sScontraeIrr$.
(iii) This implies from (i) and (ii). ■

Theorem 3.6.

Let $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \rightarrow (\mathfrak{N}, \sigma, \Lambda)$ and $\mathfrak{g} : (\mathfrak{N}, \sigma, \Lambda) \rightarrow (P, \rho, \Lambda)$ be $N_sScontraeCts$ mappings and $(\mathfrak{N}, \sigma, \Lambda)$ be a $N_sSeU_{\frac{1}{2}}$-space . Then, $\mathfrak{g} \circ \mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \rightarrow (P, \rho, \Lambda)$ is N_sSeCts.

Proof:

Consider a N_sSos $(\tilde{A}, \Lambda)$ in P. Since $\mathfrak{g}$ is $N_sScontraeCts$, $\mathfrak{g}^{-1}(\tilde{A}, \Lambda)$ is a N_sSecs in $\mathfrak{N}$. Since $(\mathfrak{N}, \sigma, \Lambda)$ is $N_sSeU_{\frac{1}{2}}$-space, $(\tilde{L}, \Lambda)$ is a N_sScs in $\mathfrak{N}$. As $\mathfrak{h}$ is $N_sScontraeCts$, $\mathfrak{h}^{-1}(\mathfrak{g}^{-1}(\tilde{A}, \Lambda))$ is a

N_sSeos in $\mathfrak{M}$. Therefore, $\mathfrak{g} \circ \mathfrak{h}$ is a N_sSeCts map. ∎

Theorem 3.7.

Consider a map $\mathfrak{h} : (\mathfrak{M}, \tau, \Lambda) \to (\mathfrak{N}, \sigma, \Lambda)$ from a N_sSt $\mathfrak{M}$ into a N_sSt $\mathfrak{N}$. Then, the following are equivalent if $\mathfrak{M}$ and $\mathfrak{N}$ are $N_sSeU_{\frac{1}{2}}$-spaces.
(i) $\mathfrak{h}$ is a $N_sScontraeIrr$ map.
(ii) $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sSeos in $\mathfrak{M}$ for every N_sSecs $(\tilde{L}, \Lambda)$ in $\mathfrak{N}$.
(iii) $N_sScl(\mathfrak{h}^{-1}(\tilde{L}, \Lambda)) \supseteq \mathfrak{h}^{-1}(N_sSint(\tilde{L}, \Lambda))$ for every N_sSs $(\tilde{L}, \Lambda)$ of $\mathfrak{N}$.

Proof:

(i) $\to$ (ii): Let $(\tilde{L}, \Lambda)$ be any N_sSecs in $\mathfrak{N}$. Then, $(\tilde{L}, \Lambda)^c$ is a N_sSeos in $\mathfrak{N}$. Since $\mathfrak{h}$ is $N_sScontraeIrr$, $\mathfrak{h}^{-1}\left((\tilde{L}, \Lambda)^c\right)$ is a N_sSecs in $\mathfrak{M}$. But $\mathfrak{h}^{-1}\left((\tilde{L}, \Lambda)^c\right) = \left(\mathfrak{h}^{-1}(\tilde{L}, \Lambda)\right)^c$. Therefore, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sSeos in $\mathfrak{M}$.

(ii) $\to$ (iii): Let $(\tilde{L}, \Lambda)$ be any N_sSs in $\mathfrak{N}$ and $N_sSint(\tilde{L}, \Lambda) \subseteq (\tilde{L}, \Lambda)$. Then, $\mathfrak{h}^{-1}(N_sSint(\tilde{L}, \Lambda)) \subseteq \mathfrak{h}^{-1}(\tilde{L}, \Lambda)$. Since $N_sSint(\tilde{L}, \Lambda))$ is a N_sSos in $\mathfrak{N}$, $N_sSint(\tilde{L}, \Lambda)$ is a N_sSeos in $\mathfrak{N}$. Therefore, $(N_sSint(\tilde{L}, \Lambda))^c$ is a N_sSecs in $\mathfrak{N}$. By hypothesis, $\mathfrak{h}^{-1}((N_sSint\ (\tilde{L}, \Lambda))^c)$ is a N_sSeos in $\mathfrak{M}$. Since $\mathfrak{h}^{-1}\left((N_sSint(\tilde{L}, \Lambda))^c\right) = \left(\mathfrak{h}^{-1}(N_sSint(\tilde{L}, \Lambda))\right)^c$, $\mathfrak{h}^{-1}(N_sSint(\tilde{L}, \Lambda))$ is a N_sSeos in $\mathfrak{M}$. Since $\mathfrak{M}$ is $N_sSeU_{\frac{1}{2}}$-space, $\mathfrak{h}^{-1}(N_sSint(\tilde{L}, \Lambda))$ is a N_sSos in $\mathfrak{M}$. Hence $N_sScl\left(\mathfrak{h}^{-1}(\tilde{L}, \Lambda)\right) \supseteq N_sScl(\mathfrak{h}^{-1}(N_sSint(\tilde{L}, \Lambda))) = \mathfrak{h}^{-1}(N_sSint(\tilde{L}, \Lambda))$. That is, $N_sScl\left(\mathfrak{h}^{-1}(\tilde{L}, \Lambda)\right) \supseteq \mathfrak{h}^{-1}(N_sSint(\tilde{L}, \Lambda))$.

(iii) $\to$ (i): Let $(\tilde{L}, \Lambda)$ be any N_sSecs in $\mathfrak{N}$. Since $\mathfrak{N}$ is $N_sSeU_{\frac{1}{2}}$-space, $(\tilde{L}, \Lambda)$ is a N_sScs in $\mathfrak{N}$ and $N_sScl(\tilde{L}, \Lambda) = (\tilde{L}, \Lambda)$. Hence $\mathfrak{h}^{-1}(\tilde{L}, \Lambda) = \mathfrak{h}^{-1}(N_sScl(\tilde{L}, \Lambda)) \supseteq N_sSint(\mathfrak{h}^{-1}(\tilde{L}, \Lambda))$. But clearly $\mathfrak{h}^{-1}(\tilde{L}, \Lambda) \supseteq N_sSint(\mathfrak{h}^{-1}(\tilde{L}, \Lambda))$. Therefore, $N_sSint\ (\mathfrak{h}^{-1}(\tilde{L}, \Lambda)) = \mathfrak{h}^{-1}(\tilde{L}, \Lambda)$. So, $\mathfrak{h}^{-1}(\tilde{L}, \Lambda)$ is a N_sSos and hence it is a N_sSeos in $\mathfrak{M}$. Thus, $\mathfrak{h}$ is a $N_sScontraeIrr$ map. ∎

4. Application using distance measure

In this section, an application in decision making problem using distance measure is given. An example of selecting candidates from the interview for a company is formulated as neutrosophic soft model problem as below. The candidates' skills are formulated as N_sSs's and the hamming distance measure is applied to calculate the distance between the interview candidates and the ideal candidate. The most desirable candidate is the one who have less distance with the ideal candidate.

Example 4.1.

There are five candidates A, B, C, D and E appearing for an interview in a company. Let $\mathfrak{M}$ denote the selection $\mathfrak{M} = \{\mathfrak{o}_1\}$. Let Λ denote the set of 5 parameters $\Lambda = \{q_1, q_2, q_3, q_4, q_5\} =$ {experience, computer knowledge, communication skill, higher education, young age}. There is a selection committee who are the decision makers. They want to interview the candidates and select the most desirable candidate by neutrosophic soft model problem. The N_sS's $(\tilde{K}_1, \Lambda), (\tilde{K}_2, \Lambda), (\tilde{K}_3, \Lambda), (\tilde{K}_4, \Lambda)$ and $(\tilde{K}_5, \Lambda)$ describe the evaluation of the five candidates A, B, C, D and E by the selection committee, respectively.

$$(\tilde{K}_1, q_1) = \{\langle \mathfrak{o}_1, (0.3, 0.5, 0.2)\rangle\}$$
$$(\tilde{K}_1, q_2) = \{\langle \mathfrak{o}_1, (0.5, 0.5, 0.2)\rangle\}$$
$$(\tilde{K}_1, q_3) = \{\langle \mathfrak{o}_1, (0.6, 0.5, 0.4)\rangle\}$$
$$(\tilde{K}_1, q_4) = \{\langle \mathfrak{o}_1, (0.7, 0.4, 0.3)\rangle\}$$
$$(\tilde{K}_1, q_5) = \{\langle \mathfrak{o}_1, (0.6, 0.7, 0.5)\rangle\}$$
$$(\tilde{K}_2, q_1) = \{\langle \mathfrak{o}_1, (0.5, 0.3, 0.1)\rangle\}$$
$$(\tilde{K}_2, q_2) = \{\langle \mathfrak{o}_1, (0.4, 0.5, 0.6)\rangle\}$$
$$(\tilde{K}_2, q_3) = \{\langle \mathfrak{o}_1, (0.7, 0.4, 0.2)\rangle\}$$
$$(\tilde{K}_2, q_4) = \{\langle \mathfrak{o}_1, (0.6, 0.7, 0.4)\rangle\}$$
$$(\tilde{K}_2, q_5) = \{\langle \mathfrak{o}_1, (0.5, 0.6, 0.6)\rangle\}$$
$$(\tilde{K}_3, q_1) = \{\langle \mathfrak{o}_1, (0.7, 0.4, 0.3)\rangle\}$$
$$(\tilde{K}_3, q_2) = \{\langle \mathfrak{o}_1, (0.4, 0.5, 0.7)\rangle\}$$
$$(\tilde{K}_3, q_3) = \{\langle \mathfrak{o}_1, (0.6, 0.3, 0.2)\rangle\}$$
$$(\tilde{K}_3, q_4) = \{\langle \mathfrak{o}_1, (0.7, 0.5, 0.4)\rangle\}$$
$$(\tilde{K}_3, q_5) = \{\langle \mathfrak{o}_1, (0.3, 0.4, 0.7)\rangle\}$$
$$(\tilde{K}_4, q_1) = \{\langle \mathfrak{o}_1, (0.7, 0.8, 0.3)\rangle\}$$
$$(\tilde{K}_4, q_2) = \{\langle \mathfrak{o}_1, (0.6, 0.6, 0.3)\rangle\}$$
$$(\tilde{K}_4, q_3) = \{\langle \mathfrak{o}_1, (0.4, 0.6, 0.6)\rangle\}$$
$$(\tilde{K}_4, q_4) = \{\langle \mathfrak{o}_1, (0.8, 0.7, 0.2)\rangle\}$$
$$(\tilde{K}_4, q_5) = \{\langle \mathfrak{o}_1, (0.7, 0.2, 0.6)\rangle\}$$
$$(\tilde{K}_5, q_1) = \{\langle \mathfrak{o}_1, (0.6, 0.4, 0.2)\rangle\}$$
$$(\tilde{K}_5, q_2) = \{\langle \mathfrak{o}_1, (0.7, 0.4, 0.3)\rangle\}$$
$$(\tilde{K}_5, q_3) = \{\langle \mathfrak{o}_1, (0.5, 0.5, 0.6)\rangle\}$$
$$(\tilde{K}_5, q_4) = \{\langle \mathfrak{o}_1, (0.6, 0.3, 0.2)\rangle\}$$
$$(\tilde{K}_5, q_5) = \{\langle \mathfrak{o}_1, (0.7, 0.5, 0.4)\rangle\}$$

The N_sS ideal solution $(\tilde{K}, \Lambda^+)$ is given by

$$(\tilde{K}, q_1) = \{\langle \mathfrak{o}_1, (1, 1, 0)\rangle\}$$
$$(\tilde{K}, q_2) = \{\langle \mathfrak{o}_1, (1, 1, 0)\rangle\}$$
$$(\tilde{K}, q_3) = \{\langle \mathfrak{o}_1, (1, 1, 0)\rangle\}$$
$$(\tilde{K}, q_4) = \{\langle \mathfrak{o}_1, (1, 1, 0)\rangle\}$$
$$(\tilde{K}, q_5) = \{\langle \mathfrak{o}_1, (1, 1, 0)\rangle\}$$

Then by Hamming distance, we have,

$$d_h((\tilde{K}_1, \Lambda), (\tilde{K}, \Lambda^+)) = 0.42$$
$$d_h((\tilde{K}_2, \Lambda), (\tilde{K}, \Lambda^+)) = 0.4467$$
$$d_h((\tilde{K}_3, \Lambda), (\tilde{K}, \Lambda^+)) = 0.5$$
$$d_h((\tilde{K}_4, \Lambda), (\tilde{K}, \Lambda^+)) = 0.3933$$
$$d_h((\tilde{K}_5, \Lambda), (\tilde{K}, \Lambda^+)) = 0.4333$$

Therefore, $d_h((\tilde{K}_4, \Lambda), (\tilde{K}, \Lambda^+)) < d_h((\tilde{K}_1, \Lambda), (\tilde{K}, \Lambda^+)) < d_h((\tilde{K}_5, \Lambda), (\tilde{K}, \Lambda^+)) < d_h((\tilde{K}_2, \Lambda), (\tilde{K}, \Lambda^+)) < d_h((\tilde{K}_3, \Lambda), (\tilde{K}, \Lambda^+))$. Then, $(\tilde{K}_4, \Lambda) \supset (\tilde{K}_1, \Lambda) \supset (\tilde{K}_5, \Lambda) \supset (\tilde{K}_2, \Lambda) \supset (\tilde{K}_3, \Lambda)$. The distance between the candidate D and the ideal solution is lesser than the other candidates. So, candidate D is ranked as top candidate among all the 5 candidates. Hence the most desirable candidate is D. The selection committee can choose the candidate D.

5. Conclusion

In this paper, $N_sScontraeCts$ map is defined using N_sSeos and its properties are analyzed. Then $N_sScontraCts$ and some new kinds of contra continuous maps are compared with $N_sScontraeCts$ maps. In addition, these maps are extended to $N_sScontraeIrr$ maps. Also, an application in decision making problem is explained with an example using distance measure. In future, these findings can be used for some mathematical applications.

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