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Journal of Interdisciplinary Mathematics

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tjim20

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To cite this article: Nadia M. Ali Abbas, Shuker Mahmood Khalil & M. Vigneshwaran (2021) The neutrosophic strongly open maps in neutrosophic bi-topological spaces, Journal of Interdisciplinary Mathematics, 24:3, 667-675, DOI: 10.1080/09720502.2020.1860287

To link to this article: https://doi.org/10.1080/09720502.2020.1860287

Published online: 29 Mar 2021.

Journal of Interdisciplinary Mathematics
ISSN: 0972-0502 (Print), ISSN: 2169-012X (Online)
Vol. 24 (2021), No. 3, pp. 667–675
DOI : 10.1080/09720502.2020.1860287

The neutrosophic strongly open maps in neutrosophic bi-topological spaces

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Abstract

In this work, some new classes of neutrosophic (1,2)-maps are investigated and discussed their basic attributions in neutrosophic bi-topological space (NBTS). In this paper, the relationships among these classes like neutrosophic (1,2)-continuous/ open/ strongly open/ generality open/ maps are discussed. Moreover, our work in this paper is examined and some examples are shown to support this research.

Subject Classification: *06D72, 03E72.*

Keywords: *Neutrosophic sets, Bi-topological spaces, (1,2)-continuous maps, (1,2)-open maps.*

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1. Introduction

The connotations of the maps in bi-topological spaces have been discussed and explained extensively in general topology see ([3], [4]). After that, some applications in general topology and non-classical topology like soft bi-topological spaces are discussed see ([5], [6]). Smarandache [7] presented the neutrosophic set / logic/ probability/ statistics, the neutrosophic set is studied in topology, algerbra and other fields. It is one of the non-classical sets, like fuzzy, nano, soft and so on, see ([8]-[35]). Next, some applications of neutrosophic set are studied see ([36]). In 2014, the connotations of "neutrosophic closed set " and "neutrosophic continuous function" are given [37]. In this work, some new classes of neutrosophic (1,2)-maps are investigated and discussed their basic attributions in (NBTS). In this paper, the relationships among these classes like neutrosophic (1,2)-continuous/open/strongly open/ generality open/ maps are discussed. Moreover, our work in this paper is examined and some examples are shown to support this research.

2. Preliminaries

Definition 2.1 : [1] Assume $\Psi \neq \varphi$. A neutrosophic set (NS) θ is defined as $\theta = \langle \alpha, \partial_{\varpi}(\alpha), \omega_{\theta}(\alpha), \ell_{\theta}(\alpha) : \alpha \in \Psi \rangle$ where $\partial_{\varpi}(\alpha)$ is the degree of membership, $\omega_{\theta}(\alpha)$ is the degree of indeterminacy and $\ell_{\theta}(\alpha)$ is the degree of non-membership, $\forall \alpha \in \Psi$ to θ.

Definition 2.2 [1] Assume θ and β are neutrosophic sets (NSs) as following

$\theta = \langle \alpha, \partial_{\varpi}(\alpha), \omega_{\theta}(\alpha), \ell_{\theta}(\alpha) : \alpha \in \Psi \rangle$ and $\beta = \langle \alpha, \partial_{\beta}(\alpha), \omega_{\beta}(\alpha), \ell_{\beta}(\alpha) : \alpha \in \Psi \rangle$. Then

(1) $\theta \subseteq \beta$ if and only if $\partial_{\varpi}(\alpha) \leq \partial_{\chi}(\alpha)$, $\omega_{\theta}(\alpha) \geq \omega_{\chi}(\alpha)$ and $\ell_{\theta}(\alpha) \geq \ell_{\chi}(\alpha)$,

(2) $\theta^{c} = \langle \alpha, \ell_{\theta}(\alpha), 1 - \omega_{\theta}(\alpha), \partial_{\theta}(\alpha) : \alpha \in \Psi \rangle$,

(3) $\theta \cup \beta = \langle \alpha, \partial_{\theta}(\alpha) \vee \partial_{\beta}(\alpha), \omega_{\theta}(\alpha) \wedge \omega_{\beta}(\alpha), \ell_{\theta}(\alpha) \wedge \ell_{\beta}(\alpha) : \alpha \in \Psi \rangle$,

(4) $\theta \cap \beta = \langle \alpha, \partial_{\theta}(\alpha) \wedge \partial_{\beta}(\alpha), \omega_{\theta}(\alpha) \vee \omega_{\beta}(\alpha), \ell_{\theta}(\alpha) \vee \ell_{\beta}(\alpha) : \alpha \in \Psi \rangle$.

Definition 2.3 : [1] 1_N and 0_N are of the form $0_N = \{\langle \alpha, (0,1,1) \rangle : \alpha \in \Psi\}$ and $1_N = \{\langle \alpha, (1,0,0) \rangle : \alpha \in \Psi\}$.

Definition 2.4 : [2] We say (Ψ, τ) is a neutrosophic topological space (NTS) if and only if τ is a collection of (NSs) in Ψ and it such that:

(1) $1_N, 0_N \in \tau$,

(2) $\theta \cap \beta \in \tau$ for any $\theta, \beta \in \tau$,

(3) $\bigcup_{i \in I} \theta_i \in \tau$ for any arbitrary family $\{\theta_i \mid i \in I\} \subseteq \tau$.

Also, any $\theta \in \tau$ is called neutrosophic open set (NOS) and we say neutrosophic closed set (NCS) for its complement.

Definition 2.5 : [2] The neutrosophic closure of (NS) $\theta = \langle \alpha, \partial_{\varpi}(\alpha), \omega_{\theta}(\alpha), \ell_{\theta}(\alpha) : \alpha \in \Psi \rangle$ is the intersection of all (NCS) containing θ and is referred by $Ncl(\theta)$. While the neutrosophic interior of θ is the union of all (NOS) is contained in θ and is referred by $N\operatorname{int}(\theta)$.

Definition 2.6 : [2] For any (NS) $\theta = \langle \alpha, \partial_{\varpi}(\alpha), \omega_{\theta}(\alpha), \ell_{\theta}(\alpha) : \alpha \in \Psi \rangle$ in (NTS) (Ψ, τ) we say that θ is a neutrosophic semi-open set (NSOS) if there exists (NOS) $\beta = \langle \alpha, \partial_{\beta}(\alpha), \omega_{\beta}(\alpha), \ell_{\beta}(\alpha) : \alpha \in \Psi \rangle$ such that $\beta \subseteq \theta \subseteq Ncl(\theta)$.

3. Neutrosophic Strongly Open Maps:

In this section, the connotations of neutrosophic (1, 2)-strongly/ generality/ open maps are investigated and their relations with neutrosophic (1, 2)-open/continuous maps are stated. Some of their applications are given. Moreover, the current work is supported by a number of examples.

Definition 3.1 : Let $\xi : (\Psi, \tau_1, \tau_2) \to (\Omega, \lambda_1, \lambda_2)$ be a neutrosophic map (NM) from a neutrosophic bi-topological space (NBTS) (Ψ, τ_1, τ_2) into (NBTS) $(\Omega, \lambda_1, \lambda_2)$, ξ is called a neutrosophic (1, 2)- continuous map (N-(1,2)-CM) if $\xi^{-1}(\beta)$ is neutrosophic (1,2)-open set (N-(1,2)-OS) in (Ψ, τ_1, τ_2) for any (N-(1,2)-OS) $\beta = \langle \varsigma, \partial_{\beta}(\varsigma), \omega_{\beta}(\varsigma), \ \ell_{\beta}(\varsigma) : \varsigma \in \Omega \rangle$ in $(\Omega, \lambda_1, \lambda_2)$.

Definition 3.2 : Let $\xi : (\Psi, \tau_1, \tau_2) \to (\Omega, \lambda_1, \lambda_2)$ be a (NM) from a (NBTS) (Ψ, τ_1, τ_2) into (NBTS) $(\Omega, \lambda_1, \lambda_2)$, ξ is called a neutrosophic (1, 2)- open map (N-(1,2)-OM) if $\xi(\beta)$ is (N-(1,2)-OS) in $(\Omega, \lambda_1, \lambda_2)$ for any (N-(1,2)-OS) $\theta = \langle \alpha, \partial_{\varpi}(\alpha), \omega_{\theta}(\alpha), \ \ell_{\theta}(\alpha) : \alpha \in \Psi \rangle$ in (Ψ, τ_1, τ_2).

Definition 3.3 : Let $\xi : (\Psi, \tau_1, \tau_2) \to (\Omega, \lambda_1, \lambda_2)$ be a (NM) from a (NBTS) (Ψ, τ_1, τ_2) into (NBTS) $(\Omega, \lambda_1, \lambda_2)$, ξ is called a neutrosophic (1, 2)-strongly open map (N-(1,2)-SOM) if $\xi(\theta) \in \lambda_1 \cup \lambda_2$ for any (NSOS) $\theta = \langle \alpha, \partial_{\varpi}(\alpha), \omega_{\theta}(\alpha), \ell_{\theta}(\alpha) : \alpha \in \Psi \rangle$ in $(\Psi, \tau_1 \cap \tau_2)$.

Example 3.4 : Let $\xi:(\Psi,\tau_1,\tau_2)\to(\Omega,\lambda_1,\lambda_2)$ be a (NM) from a (NBTS) (Ψ,τ_1,τ_2) into (NBTS) $(\Omega,\lambda_1,\lambda_2)$, where λ_1 or λ_2 is a neutrosophic discrete topology (NDT). Hence, $\lambda_1 \cup \lambda_2 = NS(\Omega)$, where $NS(\Omega)$ is the family of all the (NSs) in Ω. Hence, for any (NSOS) $\theta=\langle\alpha,\partial_{\varpi}(\alpha),\omega_\theta(\alpha),\ell_\theta(\alpha):\alpha\in\Psi\rangle$ in $(\Psi,\tau_1\cap\tau_2)$ we have $\xi(\theta)\in\lambda_1\cup\lambda_2$ and this implies that ξ is a (N-(1,2)-SOM).

Remark 3.5 : It is easy to show that each (N-(1,2)-SOM) is (N-(1,2)-OM). However, the converse is not necessary true in general.

Example 3.6 : Let $\Psi=\{s_1,s_2,s_3\}$, $\tau_1=\{1_N,0_N,\theta\}$, $\tau_2=\{1_N,0_N,\theta,\beta\}$, where $\theta=\{\langle s_1,0.5,0.1,0.6\rangle, \langle s_2,0.3,0.3,0.5\rangle, \langle s_3,0.3,0.4,0.7\rangle\}$ and $\beta=\{\langle s_1,0.7,0.1,0.2\rangle, \langle s_2,0.6,0.2,0.1\rangle, \langle s_3,0.9,0.3,0.2\rangle\}$ let $\Omega=\{a_1,a_2,a_3\}$ $\lambda_1=\lambda_2=\{1_N,0_N,C,D,E\}$, where $C=\{\langle a_1,0.6,0.2,0.7\rangle, \langle a_2,0.4,0.4,0.6\rangle, \langle a_3,0.4,0.5,0.8\rangle\}$, $D=\{\langle a_1,0.8,0.2,0.3\rangle, \langle a_2,0.7,0.3,0.2\rangle, \langle a_3,0.8,0.4,0.3\rangle\}$, and $E=\{\langle a_1,0.9,0.1,0.2\rangle, \langle a_2,0.8,0.2,0.1\rangle, \langle a_3,0.9,0.3,0.3\rangle\}$. Let $\xi:(\Psi,\tau_1,\tau_2)\to(\Omega,\lambda_1,\lambda_2)$ be a (NM), where $\xi(s_1)=a_1$, $\xi(s_2)=a_2$ and $\xi(s_3)=a_3$. Then $\xi:(\Psi,\tau_1,\tau_2)\to(\Omega,\lambda_1,\lambda_2)$ is a (N-(1,2)-OM) but not (N-(1,2)-SOM), since there is a (NSOS) H in $(\Psi,\tau_1\cap\tau_2)$ where $H=\{\langle s_1,0.5,0.1,0.6\rangle, \langle s_2,0.4,0.1,0.1\rangle, \langle s_3,0.5,0.3,0.6\rangle\}$, but $\xi(H)=T\notin\lambda_1\cup\lambda_2$, where $T=\{\langle a_1,0.5,0.1,0.6\rangle, \langle a_2,0.4,0.1,0.1\rangle, \langle a_3,0.5,0.3,0.6\rangle\}$.

Theorem 3.7 : *If $\xi:(\Psi,\tau_1,\tau_2)\to(\Omega,\lambda_1,\lambda_2)$ is (N-(1, 2)-OM) from neutrosophic discrete bi-topological space (NDBTS) (Ψ,τ_1,τ_2) into (NBTS) $(\Omega,\lambda_1,\lambda_2)$, then ξ is (N-(1,2)-SOM).*

Proof : suppose $\theta=\langle\alpha,\partial_{\varpi}(\alpha),\omega_\theta(\alpha),\ell_\theta(\alpha):\alpha\in\Psi\rangle$ is (NSOS) in (Ψ,τ_1,τ_2) we consider that θ is (N-(1,2)-OS) in (Ψ,τ_1,τ_2) [since (Ψ,τ_1,τ_2) is (NDBTS)]. Therefore, $\xi(\theta)$ is (N-(1,2)-OS) in $(\Omega,\lambda_1,\lambda_2)$ [since ξ is (N- (1, 2)-OM)], so ξ is (N- (1, 2)-OM).

Definition 3.8 : Let $\xi:(\Psi,\tau_1,\tau_2)\to(\Omega,\lambda_1,\lambda_2)$ be a (NM) from a (NBTS) (Ψ,τ_1,τ_2) into (NBTS) $(\Omega,\lambda_1,\lambda_2)$, ξ is called a neutrosophic (1, 2)-generality open map (N-(1,2)-GOM) if $\xi(\theta)$ is (NSOS) in $(\Psi,\tau_1\cap\tau_2)$ for each $\theta=\langle\alpha,\partial_{\varpi}(\alpha),\omega_\theta(\alpha),\ell_\theta(\alpha):\alpha\in\Psi\rangle$ (NSOS) in $(\Psi,\tau_1\cap\tau_2)$.

Example 3.9 : Let $\xi:(\Psi,\tau_1,\tau_2)\to(\Omega,\lambda_1,\lambda_2)$ be a (NM) from a (NBTS) (Ψ,τ_1,τ_2) onto (NBTS) $(\Omega,\lambda_1,\lambda_2)$, where τ_1 or τ_2 is a neutrosophic indiscrete topology (NIT), we have $\tau_1\bigcap\tau_2=\{1_N,0_N\}$. Therefore, for any (NSOS) $\theta=\langle\alpha,\partial_{\varpi}(\alpha),\omega_{\theta}(\alpha),\ \ell_{\theta}(\alpha):\alpha\in\Psi\rangle$ in $(\Psi,\tau_1\bigcap\tau_2)$ we have $\theta=0_N$ or 1_N and this implies that $\xi(\theta)=0_N$ or 1_N and hence ξ is a (N-(1,2)-GOM).

Remark 3.10 : It is easy to show that each (N-(1,2)-SOM) is (N- (1,2)-GOM). However, the converse is not necessary true in general.

Example 3.11 : take $\xi:(\Psi,\tau_1,\tau_2)\to(\Omega,\lambda_1,\lambda_2)$ in Example (3.6), we obtain ξ is a (N-(1,2)-OM) but not (N-(1,2)-SOM). For any (NSOS) θ in $(\Psi,\tau_1\bigcap\tau_2)$, we have there exists (NOS) β in $(\Psi,\tau_1\bigcap\tau_2)$ satisfies $\beta\subseteq\theta$ $\subseteq Ncl(\beta)$. But, $\beta\in\tau_1\cap\tau_2$, thus β can be formed by union of two (NOSs) $\beta\in\tau_1$ and $\beta\in\tau_2$. Hence β is (N-(1,2)-OS) in (Ψ,τ_1,τ_2). Therefore $\xi(\beta)$ is (N-(1,2)-OS) in $(\Omega,\lambda_1,\lambda_2)$ [since ξ is a (N-(1,2)-OM)]. Also, $\xi(\beta)\subseteq$ $\xi(\theta)\subseteq\xi(Ncl(\beta))\subseteq Ncl(\xi(\beta))$. But $\xi(\beta)\in\lambda_1\cap\lambda_2$ then $\xi(\theta)$ is (NSOS)in $(\Omega,\lambda_2\cap\lambda_2)$. Hence ξ is (N-(1,2)-GOM) but not (N-(1,2)-SOM).

Theorem 3.12 : *If $\xi:(\Psi,\tau_1,\tau_2)\to(\Omega,\lambda_1,\lambda_2)$ is (N-(1,2)-OM) and (N-(1, 2)-CM), then ξ is (N-(1,2)-GOM).*

Proof : Let $\xi:(\Psi,\tau_1,\tau_2)\to(\Omega,\lambda_1,\lambda_2)$ be a (N-(1, 2)-CM) and (N-(1,2)-OM) from a (NBTS) (Ψ,τ_1,τ_2) into (NBTS) $(\Omega,\lambda_1,\lambda_2)$, suppose $\theta=\langle\alpha,\partial_{\varpi}(\alpha),\omega_{\theta}(\alpha),\ \ell_{\theta}(\alpha):\alpha\in\Psi\rangle$ is (NSOS) in $(\Omega,\lambda_2\bigcap\lambda_2)$, then there exists (NOS) β in $(\Omega,\lambda_2\bigcap\lambda_2)$ satisfies: $\beta\subseteq\theta\subseteq Ncl(\beta)\Rightarrow$ $\xi(\beta)\subseteq\xi(\theta)\subseteq\xi(Ncl(\beta))$. In other side, the (NOS) β is a (N-(1,2)-OS) in bi-topological space (Ψ,τ_1,τ_2) since $\beta\in\tau_1\bigcap\tau_2$, we consider that $\xi(Ncl(\beta))\subseteq Ncl(\xi(\beta))$ [since ξ is (N-(1, 2)-CM)]. Moreover, $\xi(\theta)$ is (N-(1,2)-OS) in $(\Omega,\lambda_1,\lambda_2)$ [since ξ is (N-(1,2)-OM)], Then $\xi(\theta)$ is (NSOS) in $(\Omega,\lambda_2\bigcap\lambda_2)$. Therefore, ξ is (N-(1,2)-GOM).

Remark 3.13 : We can explain our results by this diagram:

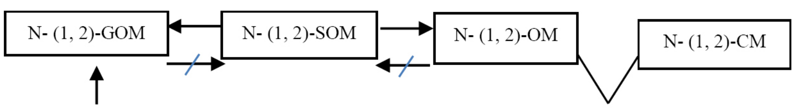

Figure 1

The relationships among four classes of the neutrosophic (1, 2)-maps

4. Conclusion

In this work, attempt has been made to apply the notion of neutrosophic maps to study some types in (NBTSs) like; neutrosophic (1,2)-continuous/ open/ strongly open/ generality open/ maps. Moreover, the properties of these new notions are investigated. We will use the soft sets theory in future work to investigate new classes of neutrosophic soft maps and then we can disuse their applications in neutrosophic soft bi- topological spaces.

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Received November, 2020

Revised January, 2021