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NANO JD*-HOMEOMORPHISMS

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Abstract: We discussed nano JD*-Homeomorphisms in nano topological spaces in this study. We address the fundamental characteristics and noteworthy characterizations of nano JD*-Homeomorphisms in nano topological spaces. Our analysis demonstrates how they relate to other ideas already known, such as nano semi-homeomorphisms, nano pre-homeomorphisms, and nano g-homeomorphisms.

Keywords and Phrases: Nano semi-homeomorphisms, nano pre-homeomorphisms, nano g-homeomorphisms and nano JD*-homeomorphisms.

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1. Introduction

The term "Nano" refers to anything extremely small. The word "Topology" comes from two Greek words: "Topos" (surface) and "Logos" (discussion or study). Nano topology, then, is the study of extremely small surfaces. Lellis Thivagar et al. [12] was the main brain behind developing the concept of *Náno* topology. The term *Náno* can be ascribed to any unit of measure. Maki. et. al. [7] introduced and generalised the notion of homeomorphism, g-homeomorphism, gc homeomorphism in topological spaces. Lellis Thivagar et al. [13] investigated Nano homeomorphism in Nano Topological spaces. Bhuvaneswari. et. al. [1] introduced and distinguished some properties of *Náno* generalised homeomorphism in *Náno* topological spaces. K . Mythili Gnanapriya [2] introduced some properties in *Náno* generalised pre-homeomorphism. Recently, several researcher were introduced and study the new notions in nano topological spaces and ideal nano topological spaces for example [[5], [6], [9], [10] and [11]]. In this paper, one such theoretical application of *Náno* JD* open sets namely *Náno* JD* homeomorphism is introduced and some of its remarkable properties are discussed.

2. Preliminaries

In this section, we present the basic definitions and results of *Náno* topological spaces which may be found in earlier studies. Throughout this paper, $(M, \tau(P))$ denotes a *Náno* topological space with respect to P ⊂ M. And, $N_n int$ and $N_n cl$ denotes the *Náno* interior and *Náno* closure in *náno* topological spaces.

Definition 2.1. [3] *A subset J of a Náno topological space $(M, \tau(P))$ is*

1. *Náno semi*-open if* $J \subseteq N_n cl^*(N_n int(J))$.
2. *Náno semi*-closed if* $M \setminus J$ *is Náno Semi*-open.*
3. *Náno pre*-open if* $J \subseteq N_n int^*(N_n cl(J))$.
4. *Náno pre*-closed if* $M \setminus J$ *is Náno Pre*-open.*
5. *Náno α*-open if* $J \subseteq N_n int^*(N_n cl(N_n int^*(J))$.
6. *Náno JD* open if* $J \subseteq N_n int^*(N_n cl(J)) \cup N_n cl^*(N_n int(J))$.
7. *Náno JD* closed if* $N_n int^*(N_n cl(J)) \cap N_n cl^*(N_n int(J)) \subseteq J$.

Definition 2.2. *Let $(M, \tau(P))$ and $(N, \tau(Q))$ be two Náno topological spaces. Then a mapping h: $(M, \tau(P)) \to (N, \tau(Q))$ is claimed to be Náno JD* continuous if $h^{-1}(J)$ is Náno JD* open in M for every Náno open set J in N.*

Definition 2.3. *Let $(M, \tau(P))$ and $(N, \tau(Q))$ be two $N\acute{a}no$ topological spaces. Then a mapping h: $(M, \tau(P)) \to (N, \tau(Q))$ is claimed to be $N\acute{a}no$ continuous if $h^{-1}(J)$ is $N\acute{a}no$ open in M for every $N\acute{a}no$ open set J in N.*

Definition 2.4. *Let $(M, \tau(P))$ and $(N, \tau(Q))$ be two $N\acute{a}no$ topological spaces. Then a mapping h: $(M, \tau(P)) \to (N, \tau(Q))$ is claimed to be $N\acute{a}no$ irresolute if $h^{-1}(J)$ is $N\acute{a}no$ open in M for every $N\acute{a}no$ open set J in N.*

Definition 2.5. *Let $(M, \tau(P))$ and $(N, \tau(Q))$ be two $N\acute{a}no$ topological spaces. Then a mapping h: $(M, \tau(P)) \to (N, \tau(Q))$ is claimed to be $N\acute{a}no$ JD* irresolute if $h^{-1}(J)$ is $N\acute{a}no$ JD* open in M for every $N\acute{a}no$ JD* open set J in N.*

Definition 2.6. *Let $(M, \tau(P))$ and $(N, \tau(Q))$ be two $N\acute{a}no$ topological spaces. Then a mapping h: $(M, \tau(P)) \to (N, \tau(Q))$ is claimed to be $N\acute{a}no$ JD* open if the image of each $N\acute{a}no$ JD* open set is $N\acute{a}no$ JD* open set.*

Definition 2.7. [13] *Let $(M, \tau(P))$ and $(N, \tau(Q))$ be two $N\acute{a}no$ topological spaces. Then a bijective mapping h: $(M, \tau(P)) \to (N, \tau(Q))$ is claimed to be $N\acute{a}no$ homeomorphism if h is both $N\acute{a}no$ open and $N\acute{a}no$ continuous.*

Definition 2.8. *Let $(M, \tau(P))$ and $(N, \tau(Q))$ be two $N\acute{a}no$ topological spaces. Then a bijective mapping h: $(M, \tau(P)) \to (N, \tau(Q))$ is claimed to be $N\acute{a}no$ α homeomorphism if h is both $N\acute{a}no$ α open and $N\acute{a}no$ α continuous.*

Definition 2.9. *Let $(M, \tau(P))$ and $(N, \tau(Q))$ be two $N\acute{a}no$ topological spaces. Then a bijective mapping h: $(M, \tau(P)) \to (N, \tau(Q))$ is claimed to be $N\acute{a}no$ g homeomorphism if h is both $N\acute{a}no$ g open and $N\acute{a}no$ g continuous.*

3. Nano JD*-homeomorphisms

In this section we define $N\acute{a}no$ JD*-homeomorphisms and discuss some of their characterizations in $N\acute{a}no$ topological spaces.

Definition 3.1. *A bijection h:$(M, \tau(P)) \to (N, \tau(Q))$ is claimed to be $N\acute{a}no$ JD*-homeomorphisms if h is both $N\acute{a}no$ JD* continuous and $N\acute{a}no$ JD* open.*
The family of all $N\acute{a}no$ JD homeomorphisms in M is denoted by $NJD^*H(M, P)$*

Example 3.2. Let M={f,t,y,u} with M/R= {{f}, {y},{t,u}} and P={f,t}.
$\tau(M) = \{U, \phi, \{f\}, \{f, t, u\}, \{t, u\}\}$.
Let N={f,t,y,u} with N/R'={{f,u},{t},{y}} and Q={t,u}.
Then $\tau(Q) = \{N, \phi, \{l, r, v\}, \{r\}\{l, v\}\}$.
Define h:M→N as h(f)=f; h(t)=t; h(y)=u; h(u)=y.
Here h is both $N\acute{a}no$ JD* continuous and $N\acute{a}no$ JD* open.
Therefore h is $N\acute{a}no$ JD* homeomorphism.

Theorem 3.3. *Let h:$(M, \tau(P)) \to (N, \tau(Q))$ be a bijective mapping, $N\acute{a}no$ JD* continuous map. Then the following statements are equivalent.*

1. *h is $N\acute{a}no$ JD* open.*
2. *h is $N\acute{a}no$ JD* Homeomorphism.*
3. *h is $N\acute{a}no$ JD* closed.*

Proof. (1)⇒(2). Obvious from the Definition 2.6.
(2)⇒(3) Let V be a $N\acute{a}no$ closed set in $(M, \tau(P))$. Then V^c is $N\acute{a}no$ open in $(M, \tau(P))$. By hypothesis, h(V^c) $= (h(V))^c$ is $N\acute{a}no$ JD* open in $(N, \tau(Q))$. That is, h(V) is $N\acute{a}no$ JD* closed in $(N, \tau(Q))$. Therefore h is $N\acute{a}no$ JD* closed.
(3)⇒(1). Let V be a $N\acute{a}no$ open set in $(M, \tau(P))$. Then V^c is $N\acute{a}no$ closed in $(M, \tau(P))$. By hypothesis,h(V^c) $= (h(V))^c$ is $N\acute{a}no$ JD* closed in $(N, \tau(Q))$. That is, h(V) is $N\acute{a}no$ JD* open in $(N, \tau(Q))$. Therefore, h is a $N\acute{a}no$ JD* open map.

Theorem 3.4. *Let h:$(M, \tau(P)) \to (N, \tau(Q))$ be a bijective function then every $N\acute{a}no$ homeomorphism is $N\acute{a}no$ JD* homeomorphism.*
Proof. Let h:$(M, \tau(P)) \to (N, \tau(Q))$ be $N\acute{a}no$ homeomorphism, then h is bijective, $N\acute{a}no$ continuous and $N\acute{a}no$ open. Also let V be a $N\acute{a}no$ open set in $(N, \tau(Q))$. Since h is $N\acute{a}no$ continuous, $h^{-1}(V)$ is $N\acute{a}no$ open in $(M, \tau(P))$. Since every $N\acute{a}no$ open set is $N\acute{a}no$ JD* open set, $h^{-1}(V)$ is $N\acute{a}no$ JD* open in $(M, \tau(P))$ which implies h is $N\acute{a}no$ JD* continuous. Let W be a $N\acute{a}no$ open set in $(M, \tau(P))$. Since h is $N\acute{a}no$ open, h(W) is $N\acute{a}no$ open in $(N, \tau(Q))$. Since every $N\acute{a}no$ open set is $N\acute{a}no$ JD* open, h(W) is $N\acute{a}no$ JD* open in $(N, \tau(Q))$ which implies h is $N\acute{a}no$ JD* continuous and $N\acute{a}no$ JD* open. Thus h is $N\acute{a}no$ JD* homeomorphism.

Remark 3.5. *The contrary of the preceding proposition isn't always true as evidenced by the following example.*

Example 3.6. Let M={s,d,f,g} with M/R= {{s,g}, {d},{f}} and P={s,d}.
$\tau(P) = \{M, \phi, \{d\}, \{s, d, g\}, \{s, g\}\}$.
Let N={l,r,w,v} with N/R'={{l},{v},{r,w}} and Q={l,r}⊆N.
Then $\tau(Q) = \{N, \phi, \{l, r, w\}, \{l\}\{r, w\}\}$.
Define h:M→N as h(s)=l; h(d)=r; h(f)=w; h(g)=v. Here h is both $N\acute{a}no$ JD* continuous and $N\acute{a}no$ JD* open. Therefore h is $N\acute{a}no$ JD* homeomorphism but h is not $N\acute{a}no$ homeomorphism as it's not $N\acute{a}no$ continuous and $N\acute{a}no$ open map.

Theorem 3.7. *Let h:$(M, \tau(P)) \to (N, \tau(Q))$ be a bijective function then every $N\acute{a}no$ α homeomorphism is $N\acute{a}no$ JD* homeomorphism.*
Proof. Let h:$(M, \tau(P)) \to (N, \tau(Q))$ be a $N\acute{a}no$ α homeomorphism, then h is

bijective, $N\acute{a}no$ α continuous and $N\acute{a}no$ α open. let V be a $N\acute{a}no$ open set in $(N, \tau(Q))$. Since h is $N\acute{a}no$ α continuous, $h^{-1}(V)$ is $N\acute{a}no$ α open in $(M, \tau(P))$. Since every $N\acute{a}no$ α open set is $N\acute{a}no$ JD* open set, $h^{-1}(V)$ is $N\acute{a}no$ JD* open in $(M, \tau(P))$ which implies h is $N\acute{a}no$ JD* continuous. Let W be a $N\acute{a}no$ open set in $(M, \tau(P))$. Since h is $N\acute{a}no$ α open, h(W) is $N\acute{a}no$ α open in $(N, \tau(Q))$. Since every $N\acute{a}no$ α open set is $N\acute{a}no$ JD* open, h(W) is $N\acute{a}no$ JD* open in $(N, \tau(Q))$ which implies h is $N\acute{a}no$ JD* continuous and $N\acute{a}no$ JD* open. Thus h is $N\acute{a}no$ JD* homeomorphism.

Remark 3.8. *The contrary of the preceding proposition isn't always true as evidenced by the following example.*

Example 3.9. Let M={s,d,f,g} with M/R= {{s,d,g}, {f}} and P={s}.
Then $\tau(P) = \{M, \phi, \{s, d, g\}, \}$.
Let N={l,r,w,v} with N/R'={{l,v},{r},{w}} and Q={r,w}⊆ N.
Then $\tau(Q) = \{N, \phi, \{r, w\}\}$. Define h:M→N as h(s)=v; h(d)=r; h(f)=w; h(g)=l. Here h is both $N\acute{a}no$ JD* continuous and $N\acute{a}no$ JD* open. Therefore h is $N\acute{a}no$ JD* homeomorphism but h is not $N\acute{a}no$ α homeomorphism as it is not $N\acute{a}no$ α continuous and $N\acute{a}no$ α open map.

Theorem 3.10. *Let h:$(M, \tau(P)) \to (N, \tau(Q))$ be a function then every $N\acute{a}no$ α^* homeomorphism is $N\acute{a}no$ JD* homeomorphism.*
Proof. Let h:$(M, \tau(P)) \to (N, \tau(Q))$ be a $N\acute{a}no$ α homeomorphism, then h is bijective, $N\acute{a}no$ α^* continuous and $N\acute{a}no$ α open. let V be a $N\acute{a}no$ open set in $(N, \tau(Q))$. Since h is $N\acute{a}no$ α^* continuous, $h^{-1}(V)$ is $N\acute{a}no$ α^* open in $(M, \tau(P))$. Since every $N\acute{a}no$ α^* open set is $N\acute{a}no$ JD* open set, $h^{-1}(V)$ is $N\acute{a}no$ JD* open in $(M, \tau(P))$ which implies h is $N\acute{a}no$ JD* continuous. Let W be a $N\acute{a}no$ open set in $(M, \tau(P))$. Since h is $N\acute{a}no$ α^* open, h(W) is $N\acute{a}no$ α^* open in $(N, \tau(Q))$. Since every $N\acute{a}no$ α^* open set is $N\acute{a}no$ JD* open, h(W) is $N\acute{a}no$ JD* open in $(N, \tau(Q))$ which implies h is $N\acute{a}no$ JD* continuous and $N\acute{a}no$ JD* open. Thus h is $N\acute{a}no$ JD* homeomorphism.

Remark 3.11. *The contrary of the preceding proposition isn't always true, as evidenced by the following example.*

Example 3.12. Let M={s,j,k,l} with M/R= {{s,j,l}, {k}} and P={s}.
Then the topology $\tau(P) = \{M, \phi, \{h, j, l\}\}$.
Let N={l,r,w,v} with V/R'={{l,v},{r},{w}} and Q={r,w}⊆N.
Then $\tau(Q) = \{N, \phi, \{r, w\}\}$. Define h:M→N as h(s)=v; h(j)=r; h(k)=w; h(l)=l. Here h is both $N\acute{a}no$ JD* continuous and $N\acute{a}no$ JD* open. Therefore h is $N\acute{a}no$ JD* homeomorphism but h is not $N\acute{a}no$ α^* homeomorphism as it is not $N\acute{a}no$ α^*

continuous and $N\acute{a}no$ α^* open map.

Theorem 3.13. *Let h:$(M,\tau(P)) \rightarrow (N,\tau(Q))$ be a function, then every $N\acute{a}no$ semi homeomorphism is $N\acute{a}no$ JD* homeomorphism.*

Proof. As h:$(M,\tau(P)) \rightarrow (N,\tau(Q))$ is $N\acute{a}no$ semi homeomorphism, we have h to be $N\acute{a}no$ irresolute and every $N\acute{a}no$ pre semi-open map is $N\acute{a}no$ JD* open we have h to be both $N\acute{a}no$ JD* continuous and $N\acute{a}no$ JD* open. Therefore, h is $N\acute{a}no$ JD* homeomorphism.

Remark 3.14. *The contrary of the preceding proposition isn't always true as evidenced by the following example.*

Example 3.15. Let M={p,r,f,d} with M/R= {{p,r,d}, {f}} and P={p}.
Then the topology $\tau(P) = \{M, \phi, \{p, r, d\}\}$.
Let N={l,r,w,v} with N/R'={{l,v},{r},{w}} and Q={r,w}⊆N. Then
$\tau(Q) = \{N, \phi, \{r, w\}\}$. Define h:M→N as h(p)=v; h(r)=r; h(f)=w; h(d)=l. Here h is both $N\acute{a}no$ JD* continuous and $N\acute{a}no$ JD* open. Therefore h is $N\acute{a}no$ JD* homeomorphism but h is not $N\acute{a}no$ semi homeomorphism.

Theorem 3.16. *Let h:$(M,\tau(P)) \rightarrow (N,\tau(Q))$ be a bijective function, then every $N\acute{a}no$ semi* homeomorphism is $N\acute{a}no$ JD* homeomorphism.*

Proof. As f:$(M,\tau(P)) \rightarrow (N,\tau(Q))$ is $N\acute{a}no$ semi* homeomorphism, we have h to be $N\acute{a}no$ semi* irresolute and $N\acute{a}no$ pre semi*-open. Since every $N\acute{a}no$ semi* irresolute is $N\acute{a}no$ JD* continuous and every $N\acute{a}no$ pre semi*-open is $N\acute{a}no$ JD* open we have h to be both $N\acute{a}no$ JD* continuous and $N\acute{a}no$ JD* open. Therefore, h is $N\acute{a}no$ JD* homeomorphism.

Remark 3.17. *The contrary of the preceding proposition isn't always true as evidenced by the following example.*

Example 3.18. Let M={t,y,u,i} with M/R= {{t,y,i}, {u}} and P={t}.
Then the topology $\tau_R(P) = \{M, \phi, \{t, y, i\}\}$.
Let N={l,r,w,v} with N/R'={{l,v},{r},{w}} and Q={r,w}⊆ N. Then $\tau(Q) = \{N, \phi, \{r, w\}\}$.
Define h:M→N as h(t)=v; h(y)=r; h(u)=w; h(i)=l. Here h is both $N\acute{a}no$ JD* continuous and $N\acute{a}no$ JD* open. Therefore h is $N\acute{a}no$ JD* homeomorphism but h is not $N\acute{a}no$ semi* homeomorphism.

Theorem 3.19. *For any bijection h:$(M,\tau(P)) \rightarrow (N,\tau(Q))$ the following statements are equivalent.*

1. *Inverse of h is $N\acute{a}no$ JD* continuous.*

2. *h is a Nano JD* open function.*

3. *h is a Nano JD* closed function.*

Proof. (1) ⇒ (2) Suppose K is a *Nano* open set in M, then by i) $h^{-1^{-1}}$(K)=h(K) is a *Nano* JD* open set in N and hence h is a *Nano* JD* open function.
(2) ⇒ (3) Suppose D is *Nano* closed in M, then M-D is *Nano* open in M. By ii), h(M-D)=N-h(D) is a *Nano* JD* open set in N, implies h(D) is a *Nano* JD* closed set in N. Therefore h is *Nano* JD* closed function.
(3)⇒ (1) Let K be a *Nano* closed set in M. By iii) h(K)= $(h^{-1})^{-1}(K)$ is a *Nano* JD* closed set in N and hence the inverse of h is *Nano* JD* continuous function.

Theorem 3.20. *If h: $(M, \tau(P)) \to (N, \tau(Q))$ is bijective and Nano JD* irresolute then the following statements are equivalent.*

1. *h is Nano JD* open.*

2. *h is Nano JD* homeomorphism.*

3. *h is Nano JD* closed.*

Proof. Identical to the proof of theorem 3.3.

Theorem 3.21. *If a bijective mapping h:$(M, \tau(P)) \to (N, \tau(Q))$ is Nano JD* homeomorphism where M and N are Nano JD* $T_{\frac{1}{2}}$ space then $NJD*cl(h^{-1}(J)) = h^{-1}(NJD*cl(J))$ for every subset J of N.*
Proof. Suppose h is a *Nano* JD* homeomorphism then h is both *Nano* JD* irresolute and *Nano* JD* open. Since NJD*cl(J) is *Nano* JD* closed in N, $h^{-1}(NJD^*cl(J))$ is a *Nano* JD* closed set in M. Since M is *Nano* JD* $T_{\frac{1}{2}}$ space, $h^{-1}(NJD^*cl(J))$ is a *Nano* JD* closed set in M. Now $f^{-1}(J) \subset h^{-1}(NJD^*cl(J))$, NJD*cl($h^{-1}(J)$) $\subset NJD^*cl(h^{-1}(NJD^*cl(J))) = h^{-1}(NJD^*cl(J))$. This implies $NJD^*cl(h^{-1}(J)) \subset h^{-1}(NJD^*cl(J))$. Again since h is *Nano* JD* homeomorphism, h^{-1} is *Nano* JD* irresolute mapping.

Since $NJD^*cl(h^{-1})(J)$ is *Nano* JD* closed set in M, $(h^{-1})^{-1}(NJD^*cl(h^{-1}(J)))$ $= h(NJD^*cl(h^{-1}(J)))$ is a *Nano* JD* closed set in N. Now $J \subset (h^{-1})^{-1}(h^{-1}(J)) \subset (h^{-1})^{-1}(NJD^*cl(h^{-1}(J))) = h(NJD^*cl(h^{-1}(J)))$. Therefore, NJD*cl(J) $\subset NJD* cl(h(NJD^*cl(h^{-1}(J)))) = h(NJD^*cl(h^{-1}(J)))$, since M is a *Nano* JD* $T_{\frac{1}{2}}$ space. Hence $h^{-1}(NJD^*cl(J)) \subseteq h^{-1}h((NJD^*cl(h^{-1}(J)))$.

Theorem 3.22. *The composition of two Nano JD* homeomorphism is Nano JD* homeomorphism.*
Proof. Let h:$(M, \tau(P)) \to (N, \tau(Q))$ and k: $(N, \tau(Q)) \to (L, \tau(O))$ be two *Nano*

JD* homeomorphism. Let G be any $N\acute{a}no$ open in L. As k is $N\acute{a}no$ JD* homeomorphism, k is $N\acute{a}no$ JD* irresolute. Therefore, $k^{-1}(G)$ is $N\acute{a}no$ JD* open in N. Now, k is $N\acute{a}no$ JD* homeomorphism, h is $N\acute{a}no$ JD* irresolute. Therefore, $h^{-1}(k^{-1}(G))$. Therefore, $(k \circ h)^{-1}(G)$ is $N\acute{a}no$ JD* open in M. Hence $k \circ h$ is $N\acute{a}no$ JD* irresolute. Let H be a $N\acute{a}no$ JD* open set in M. Consider $(k \circ h)(H) = k(h(H))$. As h is $N\acute{a}no$ JD* homeomorphism, h^{-1} is $N\acute{a}no$ JD* irresolute. Therefore h(H) is $N\acute{a}no$ JD* open in N. Now k is $N\acute{a}no$ JD* homeomorphism, k^{-1} is $N\acute{a}no$ JD* irresolute, we have k(h(H)) is $N\acute{a}no$ JD* open in M. Thus, $(k \circ h)^{-1}$ is $N\acute{a}no$ JD* irresolute. Hence $k \circ h$ is $N\acute{a}no$ JD* homeomorphism.

4. Conclusion

In this study, we introduced the concept of $N\acute{a}no$ JD* Homeomorphism and looked at its remarkable features. It has been demonstrated that it can be compared to earlier ideas. Meanwhile, it is shown that $N\acute{a}no$ JD* Homeomorphism is a novel and self-contained concept.

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