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Theory of Fixed Point on Fuzzy Metric Spaces and Their Solutions

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Abstract – The examination in this paper bargains basically with fixed point theorems and their applications. Fixed point theory on fuzzy metric space is blend of fuzzy set theory and fixed point theory. Fuzzy set theory has wide range applications because of idea of fuzzy set and fuzzy logic. The present paper is gone for acquiring a fixed point theorem on fuzzy metric space which fulfills a contractive condition. We are utilizing the idea of finish metric spaces in this theorem. Our result expands and sums up some result in fuzzy metric spaces. We likewise outfit an example which fulfills our primary result in this paper.

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INTRODUCTION

All things considered, models, numerous frameworks are identified with 'uncertainty' and additionally 'inexactness'. The issue of 'inexactness' is considered when all is said in done as correct science, though that of 'uncertainty' is ambiguous or fuzzy and unintentional. Fuzzy idea is a creative innovation that upgrades customary frameworks structure with engineering skill. The use of fuzzy set; theory matches everyday substances. It is superior to the standard set theory since every one of the wonders and perceptions rail have in excess of two positive states.

FUZZY metric space is a speculation of metric space. The investigation on uncertainty and on irregularity started to investigate with the idea of fluffiness in arithmetic. Fuzzy set is utilized in fuzzy metric space, which is started by Lofti. A. Zadeh. After that Kramosil and Michalek presented the idea of fuzzy metric space. A critical idea of fuzzy metric space with ceaseless tnorm is laid by Georage and Veeramani. Grabiec broadened established fixed point theorems of Banach and Edelstein to finish and minimal fuzzy metric spaces separately. Good mapping is summed up from commutatively mappings by Jungck. After that Jungck and Rhodes started the thought of powerless good and demonstrated that perfect maps are pitifully perfect yet talk isn't valid. A typical E.A property is the speculation of the idea of non similarity is presented under strict contractive conditions by Aamri and El. Moutawakil.

In present time, Fuzzy set theory and Fuzzy logic isn't just dynamic field of research in science yet in addition in other field of engineering, drug, correspondence, material science, science and so forth are field in which the materialness of fuzzy theory was acknowledged. Since, Many creators with respect to the theory of fuzzy sets and its applications have built up a ton of writing.

Fuzzy sets are taken up with energy by designers, PC researchers and activities scientists, especially in Japan where fuzzy controllers are presently a basic piece of many assembling gadgets. A remarkable reason is the relationship that the fuzzy sets have a multi-esteemed logic, offering choice conceivable outcomes, for example, 'might be valid' and 'might be false', appropriately evaluated notwithstanding the customary division of genuine or false.

Fixed point theorems in fuzzy arithmetic are rising with lively expectation and crucial trust. The investigation of Kramosil and Michalek's of fuzzy metric space made ready for exceptionally calming hardware to create fixed point theorems for contractive kind maps. Uses of fuzzy fixed points develops in the fields guess theory, min-max issues, numerical financial matters, variational disparities, eigen esteem issues and limit esteem issues.

The fuzzy metric space was presented by O.Kramosil and J. Michalek in 1975. Helpern in 1981first demonstrated a fixed point theorem for fuzzy mappings. Additionally M.Grabiec in 1988 demonstrated the compression rule in the setting of the fuzzy metric spaces. In addition, A. George and P. Veeramani in1994 altered the idea of fuzzy metric spaces with the assistance of t-standard, by summing up the idea of probabilistic metric space to fuzzy circumstance. Therefore at the appointed time of time some metric fixed point results were summed up to fuzzy metric spaces by different creators.

Gahler in a progression of papers examined 2-metric spaces. Sharma, Sharma and Iseki considered out of the blue withdrawal type mappings in 2-metic space.

We realize that that 2-metric space is a genuine esteemed capacity of a point triples on a set X, which unique properties were proposed by the region work in Euclidean spaces. Presently it is normal to expect 3-Metric space, which is recommended by the volume work.

In the present paper we are demonstrating a typical fixed point theorem for fuzzy3-metric spaces for feebly driving mappings.

FUZZY METRIC SPACES

In 1975, Kramosil and Michálek first presented the idea of a fuzzy metric space, which can be viewed as a speculation of the measurable (probabilistic) metric space. Unmistakably, this work gives an imperative premise to the development of fixed point theory in fuzzy metric spaces. A short time later, Grabiec characterized the fulfillment of the fuzzy metric space and stretched out the Banach compression theorem to G-finish fuzzy metric spaces. Following Grabiec's work, Fang (1992) further settled some new fixed point theorems for contractive sort mappings in G-finish fuzzy metric spaces. Before long, Mishra et al. (1994) likewise acquired a few normal fixed point theorems for asymptotically driving maps in a similar space, which sum up a few fixed point theorems in metric, Menger, fuzzy and uniform spaces. Other than these works dependent on the G-finish fuzzy metric space, George and

Veeramani (1994) changed the definition of the Cauchy succession presented by Grabiec (1988) in light of the fact that even R isn't finished with Grabiec's fulfillment definition. In the interim, they marginally adjusted the thought of a fuzzy metric space presented by Kramosil and Michálek and afterward characterized a Hausdorff and first countable topology. From that point forward, the idea of a total fuzzy metric space displayed by George and Veeramani has developed as another portrayal of culmination, and some fixed point theorems have additionally been built based on this metric space. From the above examination, we can see that there are numerous investigations identified with fixed point theory dependent on the over two sorts of finish fuzzy metric spaces. Note that each G-finish fuzzy metric space is M-finished; the development of fixed point theorems in M-finish fuzzy metric spaces is by all accounts increasingly significant.

The reason for this work is to propose another class of self-maps by utilizing a ϕ-work. All the more vitally, we demonstrate the presence of a fixed point for these self-maps in M-finish fuzzy metric spaces and minimized fuzzy metric spaces in the faculties of George and Veeramani, separately.

Preliminaries -

Presently, we start with some fundamental ideas. Give N a chance to signify the set of every single positive whole number.

Definition 1. A paired task * : $[0,1] \times [0,1] \to [0,1]$ is known as a ceaseless t-standard on the off chance that it fulfills the accompanying conditions:

(TN-1) * is commutative and acquainted:

(TN-2) * is ceaseless;

(TN-3) a* 1 = a for each an e [0. 1];

(TN-4) $a * b \le c * d$ each time $a \le c, b \le d$ and $a, b, c, d \in [0, 1]$.

Definition 2. A fuzzy metric space is an arranged triple (X,M,) with the end goal that X is a (nonempty) set, * is a ceaseless t-standard and M is a fuzzy set on* $X \times X \times (0, \infty)$ *filling the consequent conditions, for all* $x, y, z \in X$, *s,t > 0:*

(FM-1) M(x,y,f) > 0;

(FM-2) M(x,y, f) = 1 if and only if x =*y*

(FM-3) M(x,y, *t)* = M(y, *x, t);*

(FM-4) $M(x, y, t) * M(y, z, s) \le M(x, z, t + s)$;

(FM-5) $M(x, y, \cdot) : (0, \infty) \to (0, 1]$ is continuous.

Definition 3. Let (X, M, *) be a fuzzy metric space. At that point:

(i) A succession $\{x_n\}$ is said to unite to x in X, indicated by $x_n \to x$, if and just if $\lim_{n\to\infty} M(x_n, x, t) = 1$ for all t > 0, i.e. for each $r \in (0, 1)$ and f > 0, there exists $n_0 \in \mathbb{N}$ with the end goal that $M(x_n, x, t) > 1 - r$ for all $n \ge n_0$.

(ii) A grouping {xn} in X is a M-Cauchy arrangement if and if for each $\epsilon \in (0, 1), t > 0$, there exists $n_0 \in \mathbb{N}$ with the end goal that $M(x_m, x_n, t) > 1 - \epsilon$ for any $m, n \ge n_0$.

(iii) The fuzzy metric space (X, M, *) is called M-finish if each M-Cauchy grouping is concurrent.

Definition 4. A fuzzy metric space (X, M, *) is minimized if each arrangement in M has a united subsequence.

Results -

In this segment, we will set up a few fixed point theorems for self-maps of the M-finish fuzzy metric space and minimal fuzzy metric space. In these metric spaces, a capacity $\varphi : [0, 1] \to [0, 1]$ which is utilized by changing the separation between two points fulfills the accompanying properties:

(PI) φ is entirely diminishing and left nonstop:

(P2) $\varphi(\lambda) = 0$ if and just If $\lambda = 1$.

Clearly, we acquire that (Lim Lemda-1)

Theorem 1. Let (X. M, *) be a M-finish fuzzy metric space and T a self-guide of X and assume that $\varphi : [0, 1] \to [0, 1]$

fulfills the prior properties (PI) and (P2). Moreover, let k be a capacity from $(0, \infty)$ into (0, 1). In the event that for any t > 0, T fulfills the accompanying condition:

$$\varphi(M(Tx, Ty, t)) \le k(t) \cdot \varphi(M(x, y, t)), \qquad (1)$$

Where $x, y \in X$ and, $x \neq y$, at that point T has an extraordinary fixed point.

proof. Let*o be a point in X. Characterize $x_{n+1} = Tx_n$ and $\tau_n(t) = M(x_n, x_{n+1}, t)$ for all $n \in \mathbb{N} \cup \{0\}$, t > 0. Now we first demonstrate that T has a fixed point. The confirmation is separated into two cases. Case 1. On the off chance that there exists $n_0 \in \mathbb{N} \cup \{0\}$ such that $x_{n_0+1} = x_{n_0}$, i.e., $Tx_{n_0} = x_{n_0}$, at that point it pursues that x_{n_0} is a fixed point of T. Case 2. We accept that $0 < \tau_n(t) < 1$ for each. That is to state, the relationship $x_n \neq x_{n+1}$ remains constant for every n. From (1), for each t > 0, we can get

$$\begin{aligned}\varphi(\tau_n(t)) &= \varphi(M(x_n, x_{n+1}, t)) \\ &= \varphi(M(Tx_{n-1}, Tx_n, t)) \le k(t) \cdot \varphi(\tau_{n-1}(t)) < \varphi(\tau_{n-1}(t)).\end{aligned} \qquad (2)$$

Since φ is entirely diminishing, it is anything but difficult to demonstrate that $\{\tau_n(t)\}$ is an increasing arrangement for each t > 0 regarding n.

We put $\lim_{n\to\infty} \tau_n(t) = \tau(t)$ and suppose that $0 < \tau(t) < 1$. By (2), then $\tau_n(t) \le \tau(t)$ infers that

$$\varphi(\tau_{n+1}(t)) \le k(t) \cdot \varphi(\tau_n(t)). \qquad (3)$$

For each t, by assuming that $n \to \infty$, since φ is left constant, we have

$$\varphi(\tau(t)) \le k(t) \cdot \varphi(\tau(t)) < \varphi(\tau(t)), \qquad (4)$$

which is a logical inconsistency. Consequently $\tau(t) \equiv 1$. That is, the grouping $\{\tau_n(t)\}$ meets to 1 for any t > 0.

Next, we demonstrate that the succession $\{x_n\}$ is a M-Cauchy arrangement. Assume that it isn't. At that point there exist $0 < \epsilon < 1$ and two successions {p(n)} and {q(n)} with the end goal that for each $n \in \mathbb{N} \cup \{0\}$ and t>0, we acquire that

$$p(n) > q(n) \ge n,$$

$$M(x_{p(n)}, x_{q(n)}, t) \le 1 - \epsilon,$$

$$M(x_{p(n)-1}, x_{q(n)}, t) > 1 - \epsilon. \qquad (5)$$

$$M(x_{p(n)-1}, x_{q(n)-1}, t) > 1 - \epsilon,$$

For each $n \in \mathbb{N} \cup \{0\}$, we suppose that $s_n(t) = M(x_{p(n)}, x_{q(n)}, t)$; then we have $1 - \epsilon \ge s_n(t) = M(x_{p(n)}, x_{q(n)}, t) \ge M(x_{p(n)-1}, x_{p(n)}, t/2)$ $* M(x_{p(n)-1}, x_{q(n)}, t/2) > \tau_{p(n)}(t/2) * (1 - \epsilon)$. (6)

Since $\tau_n(t/2) \to 1$ as $n \to \infty$ for every *t*, supposing that $n \to \infty$, we note that $\{s_n(t)\}$ converges to $1 - \epsilon$ for any *t* > 0.

Moreover, by (1), we have

$$\varphi(M(x_{p(n)}, x_{q(n)}, t)) \le k(t) \cdot \varphi(M(x_{p(n)-1}, x_{q(n)-1}, t)) < \varphi(M(x_{p(n)-1}, x_{q(n)-1}, t)). \qquad (7)$$

According to the monotonicity of φ, we know that $M(x_{p(n)}, x_{q(n)}, t) > M(x_{p(n)-1}, x_{q(n)-1}, t)$ for each n. Thus, on the basis of the formula (5) we can obtain

$$1 - \epsilon \ge M(x_{p(n)}, x_{q(n)}, t) > M(x_{p(n)-1}, x_{q(n)-1}, t) > 1 - \epsilon. \qquad (8)$$

Clearly, this leads to a contradiction.

In particular, we consider another case. That is, there exists $n_0 \in \mathbb{N} \cup \{0\}$ such that $M(x_m, x_n, t) \le 1 - \epsilon$ for all $m, n \ge n_0$.

Obviously, for any $p \in \mathbb{N}$, we know that $M(x_{n_0+p+2}, x_{n_0+p+1}, t) \le 1 - \epsilon$. As φ is monotonic, it is easy to see that the sequence $\{M(x_{n_0+p+2}, x_{n_0+p+1}, t)\}$ is a monotone and bounded sequence with respect to p. Therefore, there exists $\alpha \in (0, 1 - \epsilon]$ such that $\lim_{p\to\infty} M(x_{n_0+p+2}, x_{n_0+p+1}, t) = \alpha$ for all *t* > 0. Thus, we can obtain

$$\varphi(M(x_{n_0+p+2}, x_{n_0+p+1}, t)) \le k(t) \cdot \varphi(M(x_{n_0+p+1}, x_{n_0+p}, t)). \qquad (9)$$

By supposing that $p \to \infty$, we have $\varphi(\alpha) \le 0$, which is also a contradiction.

Hence {x_n} is an M-Cauchy sequence in the M-complete fuzzy metric space X. Therefore, we conclude that there exists a point $x \in X$ such that $\lim_{n\to\infty} x_n = x$.

Now we will show that *x* is a fixed point of T. Since $0 < \tau_n(t) < 1$, there exists a subsequence $\{x_{r(n)}\}$ of $\{x_n\}$ such that $x_{r(n)} \neq x$ for every $n \in \mathbb{N}$. From (2), we can obtain

$$0 \le \varphi(M(x_{r(n)+1}, Tx, t)) = \varphi(M(Tx_{r(n)}, Tx, t)) \le k(t)\cdot\varphi(M(x_{r(n)}, x, t)). \quad (10)$$

By supposing that $n \to \infty$ in (10), we have

$$0 \le \varphi(M(x, Tx, t)) \le k(t)\cdot\varphi(M(x, x, t)) = k(t)\cdot\varphi(1) = 0. \quad (11)$$

So we can get $\varphi(M(x, Tx, t)) = 0$. According to the property (P2), it is easy to show that $M(x, Tx, t) = 1$, i.e., $Tx = x$. Furthermore, we claim thatx is the unique fixed point of T. Assume thaty $(\neq x)$ is another fixed point of T, we then obtain

$$\varphi(M(x, y, t)) = \varphi(M(Tx, Ty, t)) \le k(t)\cdot\varphi(M(x, y, t)) < \varphi(M(x, y, t)), \quad (12)$$

which is a contradiction. The proof of the theorem is now completed.

FIXED POINT THEOREMS IN FUZZY METRIC SPACES USING (CLRG) PROPERTY

The idea of fuzzy sets was presented by Zadeh, in 1965, as another approach to speak to the unclearness in regular daily existence. In numerical programming issues are communicated as advancing some objective capacity given certain limitations, and there are genuine issues that think about various destinations. By and large it is exceptionally hard to get an attainable arrangement that conveys us to the ideal of every single target work. A conceivable technique for goals that is very valuable is the one utilizing fuzzy sets. It was created widely by numerous creators and Used in different fields to utilize this idea in topology and examination. George and Veeramani changed the idea of fuzzy metric space presented by Kramosil and Michalek so as to get the Hausdorff topology. Jungck presented the idea of good maps for a couple of self mapping. The significance of CLRg property guarantees that one doesn't require the closeness of range subspaces.

In 2008 Altun I. demonstrated normal fixed point theorem on fuzzy metric space with a certain connection. Sintunavarat presented another idea of property (CLRg). Chauhan et al use the thought of normal limit go property to demonstrate bound together fixed point theorems for pitifully good mapping in fuzzy metric spaces. Verifiable connection and (CLRg) property are utilized as an apparatus for discovering normal fixed point of compression maps. The goal of this paper is to build up the idea of E.A. property and (CLRg) property for coupled mappings and an agreed answer of inquiry raised by Rhoades . The significance of (CLRg) property guarantees that one doesn't Require the closeness of range subspaces., First, we give a few definitions.

Preliminaries:-

Definitions 1. A double task *: [0, 1] x [0, 1] [0, 1] is known as a t - standard if ([0, 1], *) is an abelian topological monoid with unit 1 to such an extent that $a * b \le c * d$

at whatever point $a \le c$ and $b \le d$ for $a, b, c, d \in [0, 1]$ Examples of t-standards are a * b = abdominal muscle and a * b = min {a, b}

Definition 2. The 3-tuple (X, M, *) is said to be a fuzzy metric space, if X is a subjective set.* is a ceaseless t-standard and M is a fuzzy set in $X^2 \times [0, \infty)$ fulfilling the accompanying conditions:

for all $x, y, z \in X$ and s, t > 0.

(FM-1) M(x, y,0) = 0,

(FM-2) M(x, y,t) = 1 for all t > 0 if and only if x = y,

(FM-3) M(x, y,t) = M(y. x. t).

(FM-4) M(x, y,t) * M(y. z, s)$\le$M(x. z, t + s),

(FM-5) M(x, y,•): [0, ∞) $\longrightarrow$ [0.1] is left continuous,

(FM-6) $\lim_{n\to\infty} M(x, y, t) = 1$.

Note that M(x, y, t) can be considered as the level of closeness among x and y as for t. we recognize x=y with M(x, y, t)=l for all t>0.The following example demonstrates that each metric space instigates a Fuzzy metric space.

Example 1 Let (X, d) be a metric space. Characterize a * b =min {a. b} and $M(x, y, t) = \frac{t}{t+d(x,y)}$ for all and all t > O.Hien (X, M, *) is a fuzzy metric space. It is known as the fuzzy metric space prompted by the metric d.

Lemma 1 Let (X, M, *) be a fuzzy metric space. On the off chance that there exist $k \in (0, 1)$ with the end goal that M(x, y, kt) $\ge$ M(x, y, t) for all x,y $\in$ X and t>0 then x = y.

Definition 3 A grouping {xn} in X is said to be a Cauchy succession if and if for each $\varepsilon > 0, t > 0$, there Exists $n_0 \in N$ such that $M(x_n, x_m, t) > 1\text{-}\varepsilon$ for all $n, m \geq n_0$.

A grouping {xn} is said to be a join to a point x in X if and if for each $\varepsilon > 0$, t > 0 there exists $n_0 \in N$ with the end goal that $M(x_n, x, t) > 1\text{-}\varepsilon$ for all $n \geq n_0$.

A Fuzzy metric space (X, M,*) is said to be finished if each Cauchy succession in it merges to a point in it.

Definition 4 Two maps An and B from a fuzzy metric space (X, M, *) into itself are said to be perfect if $\lim_{n\to\infty} M(ABx_n, BAx_n, t) = 1$ for all t > 0. at whatever point {xn} is a grouping with the end goal that $\lim_{n\to\infty} Ax_n = \lim_{n\to\infty} Bx_n = x$ for a few $x \in X$.

Definition 5 Two maps An and B from a fuzzy metric space (X, M, *) into itself are said to be feeble - perfect in the event that they drive at their occurrence points, i.e., Ax = Bx suggests ABx = BAx.

Definition 6 Self mappings An and S of a fuzzy metric space (X, M,*) are said to be once in a while feebly good (owe) if and just if thare is a point x in X which is fortuitous event point of An and S at which An and S drive.

Definition 7 A couple of self mappings An and S of a fuzzy metric space (X,M ,*) is said to fulfill the (CLRg) property if there exists a succession {xn} in X to such an extent that $\lim_{n\to\infty} Ax_n = \lim_{n\to\infty} Bx_n = Bu$ for a few $u \in X$.

Proposition 1. greetings a fuzzy metric space (X, M,*) limit of an arrangement is one of a kind.

Proposition 2 Let S and T be perfect self maps of a fuzzy metric space (X, M, *) and let {xn} be an arrangement in X to such an extent that $Sx_n, Tx_n \to u$ for some u in X. At that point $STx_n \to Tu$ if T is consistent.

Proposition 3 Let S and T be good self maps of a fuzzy metric space (X, M,*) and Su=Tu for some u in X then STu=TSu=SSu=TTu.

Lemma 1 Let (X, M,*) be a fuzzy metric space. At that point for all $x, y \in X$, $M(x,y,\cdot)$ is a non-diminishing capacity.

Lemma 2 Let (X, M, *) be a fuzzy metric space. If there exits $k \in (0,1)$ such that for all $x, y \in X$ $M(x,y,kt) \geq M(x,y,t)$ $\forall t > 0$ then x=y.

Lemma 3 Let $\{x_a\}$ be a sequence in a fuzzy metric space(X, M, *). If there exists a number $k \in (0,1)$ such that $M(x_{n+2}, x_{n+1}, kt) \geq M(x_{n+1}, x_n, t)$ $\forall t > 0$ and $n \in N$.

Then $\{x_n\}$ is a Cauchy sequence in X.

Lemma 4 The only t-nonn * satisfying $r * r \geq r$ for all $r \in [0,1]$ is the minimum t-nonn. That is a*b=min{a, b} for all $a, b \in [0,1]$.

Result-

Theorem 1. Let (X, M. *) be a Fuzzy Metric Space, * being continuous t-nonn with $a*b \geq ab$, $\forall a,b \in [0,1]$. Let $P, Q: X \times X \to X$ and $R, S: X \times X \to X$ be four mappings satisfying

following conditions:

(i) The pairs (P, R) and (Q, S) satisfy CLRg property

(ii) $M(P(x,y), Q(u,v), kt) \geq$ $\emptyset\{M(Rx, Su, t) \times M(P(x,y), Rx, t) \times M(Q(u,v), Su, t)\}$ $\forall x, y, u, v \in X, k \in (0,1)$ and $\phi : [0,1] \to [0,1]$

Such that $\emptyset(t) > t$ for 0 < t <l.Then (P. R) and (Q, S) have point of coincidence. Moreover if the pairs (P, R) and (Q, S) are occasionally weakly compatible, then there exists unique x in X.

Such that P(x,x) = S(x) = Q(x,x) = R(x) = x.

Proof: - Since the pairs (P,R) and (Q,S) satisfy CLRg property, there exist sequences $\{x_n\}$, $\{y_n\}$ $\{x_n'\}$and $\{y_n'\}$ in X such that

$$\lim_{n\to\infty} P(x_n, y_n) = \lim_{n\to\infty} R(x_n) = Ra,$$

$\lim_{n\to\infty} P(y_n, x_n) = \lim_{n\to\infty} R(y_n) = Rb$ and $\lim_{n\to\infty} Q(x_n', y_n') =$ $\lim_{n\to\infty} S(x_n') =$ Sa', $\lim_{n\to\infty} Q(y_n', x_n') = \lim_{n\to\infty} S(y_n') = Sb$,

for some a, b, a', b' in X.

CONCLUSION

The examination is focused on a couple of new sorts of fixed point theorems in fuzzy metric spaces together with their applications. In this examination, we have shown the most basic fixed point theorems in the descriptive examination of issues in the associated science. Uses of such theorems in the certified conditions can't be blocked. We are foreseeing work with these viewpoints in our future examinations.

In this work, we proposed another class of self-maps by adjusting the separation between two points in fuzzy condition, in which the - work was utilized. Based on this sort of self-delineate, further demonstrated some fixed point theorems in Mcomplete fuzzy metric spaces and smaller fuzzy metric spaces. Clearly, the present examination enhances our insight into fixed points in M-fuzzy metric spaces.

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