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New Contraction Mappings in Dislocated Quasi - Metric Spaces

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ABSTRACT
In this paper the concept of new contraction mappings has been used in proving fixed point theorems. We establish some common fixed point theorems in complete dislocated quasi metric spaces using new contraction mappings.
Keywords: Dislocated quasi-metric space; fixed point; dq-Cauchy sequence.

I. INTRODUCTION

P.Hitzler , introduced the notation of dislocated metric spaces in which self distance of a point need not be equal to zero. They also generalized the famous Banach contraction principle. Since this principle has been extended and generalized in various ways by putting contractive conditions either on the mappings or on the spaces. Dislocated metric space plays very important role in topology, logical programming and in electronics engineering. Zeyada et al. (5) initiated the concept of dislocated quasi-metric space and generalized the result of Hitzler and Seda in dislocated qusi-metric spaces. Results on fixed points in dislocated and dislocated quasi-metric spaces followed by Isufati (1) and Aage and Salunke (4) , and recently by Shrivastava , Ansari and Sharma(8). Our result generalizes some results of fixed points.

II. PRELIMINARIES

Definition 2.1: Let X be a nonempty set, let $d : X \times X \to [0,\infty)$ be a function satisfying following conditions.
(i) $d(x,y) = d(y,x) = 0$ implies $x = y$.
(ii) $d(x,y) \le d(x,z) + d(z,y)$ for all $x, y, z \in X$.
Then d is called a dislocated quasi metric spaces or dq - metric on X.

Definition 2.2: A sequence $\{x_n\}$ in dq-metric space (X , d) is said to be a Cauchy sequence if for given $\in > 0$, there exists $n_0 \in N$ such that for all $m , n \ge n_0$, implies $d(x_m, x_n) < \in$.

Definition 2.3: A sequence $\{x_n\}$ in dq-metric space (X , d) is said to be a convergent to x if $\lim_{n\to\infty} d(x_n, x) = 0$.

Definition 2.4 : A dq-metric space (X , d) is said to be a Complete if every Cauchy sequence in convergent in X .

Definition 2.5 : Let (X,d) be a dq-metric space . A mapping $f : X \to X$ is called contraction if there exists $0 \le \lambda < 1$ such that $d[f(x), f(y)] \le \lambda\, d(x,y)$ for all $x, y \in X$.

Lemma 2.6: dq-limits in a dq-metric space are unique.

Theorem 2.7: Let (X,d) be complete dq-metric space and let $f : X \to X$ be a continuous contraction function then f has a unique fixed point.

III. MAIN RESULTS

Theorem 3.1: Let (X , d) be a complete dislocated quasi metric space .Let T be a continuous mapping from X to X satisfying the following condition

$$d(Tx, Ty) \le \alpha\, d(x,y) + \beta\left(\frac{d(y,Tx) + d(x,Ty)}{1 + d(y,Ty)\; d(y,Tx)}\right) \qquad .....(1)$$

for all $x, y \in X$, $\alpha, \beta > 0$ *and* $\alpha + 2\beta < 1$. Then T has a unique fixed point.

Proof: Let { x_n} be a sequence in X , defined as follows
Let $x_0 \in X$, $Tx_0 = x_1$, $Tx_1 = x_2$,............... , $Tx_n = x_{n+1}$.
Consider

$$d(x_n, x_{n+1}) = d(Tx_{n-1}, Tx_n)$$

$$\leq \alpha\, d(x_{n-1}, x_n) + \beta\left(\frac{d(x_n, Tx_{n-1}) + d(x_{n-1}, Tx_n)}{1 + d(x_n, Tx_n)\, d(x_n, Tx_{n-1})}\right)$$

$$\leq \alpha\, d(x_{n-1}, x_n) + \beta\left(\frac{d(x_n, x_n) + d(x_{n-1}, x_{n+1})}{1 + d(x_n, x_{n+1})\; d(x_n, x_n)}\right)$$

$$\leq \alpha\, d(x_{n-1}, x_n) + \beta\, d(x_{n-1}, x_{n+1})$$

$$(1-\beta)\, d(x_n, x_{n+1}) \leq (\alpha + \beta)\, d(x_{n-1}, x_n)$$

$$d(x_n, x_{n+1}) \leq \left(\frac{\alpha + \beta}{1-\beta}\right) d(x_{n-1}, x_n)$$

$$d(x_n, x_{n+1}) \leq h\; d(x_{n-1}, x_n) ....(2) \quad \text{where} \quad h = \left(\frac{\alpha + \beta}{1-\beta}\right) < 1$$

In the same way, we have $d(x_{n-1}, x_n) \leq h\; d(x_{n-2}, x_{n-1})$.

By (2), we get $d(x_n, x_{n+1}) \leq h^2\; d(x_{n-2}, x_{n-1})$ Continue this process, we get in general $d(x_n, x_{n+1}) \leq h^n\; d(x_1, x_0)$. *Since* $0 \leq h < 1$ *as* $n \to \infty$, $h^n \to 0$. Hence {x_n } is a dq– cauchy sequence in X . Thus { x_n} dislocated quasi converges to some u in X . Since T is continuous we have T(u) = lim T(x_n) = lim x_{n+1} = u .Thus u is a fixed point T.

Uniqueness: Let y* be another fixed point of T in X , then Ty*= y* and Tx*= x*.

Now, $$d(Tx^*, Ty^*) \leq \alpha d(x^*, y^*) + \beta\left(\frac{d(y^*, Tx^*) + d(x^*, Ty^*)}{1 + d(y^*, Ty^*)\; d(y^*, Tx^*)}\right) \quad .....(3)$$

$$d(x^*, y^*) \leq \alpha d(x^*, y^*) + \beta\left(\frac{d(y^*, x^*) + d(x^*, y^*)}{1 + d(y^*, y^*)\; d(y^*, x^*)}\right)$$

$$d(x^*, y^*) \leq \alpha d(x^*, y^*) + 2\beta d(x^*, y^*)$$

$$d(x^*, y^*) \leq (\alpha + 2\beta) d(x^*, y^*)$$

This is true only when d(x*, y*)=0. Similarly d(y*, x*)=0. Hence d(x*, y*)= d(y*, x*)=0 and so x* = y* . Hence T has a unique fixed point.

Theorem 3.2: Let (X , d) be a complete dislocated quasi metric space .Let T be a continuous mapping from X to X satisfying the following condition

$$d(Tx, Ty) \leq \alpha \frac{d(y, Ty)[1 + d(x, Tx)]}{1 + d(x, y)} + \beta\left(\frac{d(y, Tx) + d(x, Ty)}{1 + d(y, Ty)\; d(y, Tx)}\right) + \gamma\; d(x, y) \quad .....(1)$$

for all $x, y \in X$, $\alpha, \beta, \gamma > 0$ *and* $\alpha + 2\beta + \gamma < 1$. Then T has a unique fixed point.

Proof: Let { x_n} be a sequence in X , defined as follows
Let $x_0 \in X$, $Tx_0 = x_1$, $Tx_1 = x_2$,............... , $Tx_n = x_{n+1}$.
Consider

$$d(x_n, x_{n+1}) = d(Tx_{n-1}, Tx_n)$$

$$\leq \frac{\alpha\, d(x_n, Tx_n)\,[1 + d(x_{n-1}, Tx_{n-1})]}{1 + d(x_{n-1}, x_n)} + \beta\left(\frac{d(x_n, Tx_{n-1}) + d(x_{n-1}, Tx_n)}{1 + d(x_n, Tx_n)\, d(x_n, Tx_{n-1})}\right) + \gamma\, d(x_{n-1}, x_n)$$

$$\leq \frac{\alpha d(x_n, x_{n+1})\,[1 + d(x_{n-1}, x_n)]}{1 + d(x_{n-1}, x_n)} + \beta\left(\frac{d(x_n, x_n) + d(x_{n-1}, x_{n+1})}{1 + d(x_n, x_{n+1})\; d(x_n, x_n)}\right) + \gamma\, d(x_{n-1}, x_n)$$

$$\leq \alpha\, d(x_n, x_{n+1}) + \beta\, d(x_{n-1}, x_{n+1}) + \gamma\, d(x_{n-1}, x_n)$$

$$(1-\alpha-\beta)\, d(x_n, x_{n+1}) \le (\beta+\gamma)\, d(x_{n-1}, x_n)$$

$$d(x_n, x_{n+1}) \le \left(\frac{\beta+\gamma}{1-\alpha-\beta}\right) d(x_{n-1}, x_n)$$

$$d(x_n, x_{n+1}) \le h\ d(x_{n-1}, x_n) \ldots\ldots(2) \quad where \quad h = \left(\frac{\beta+\gamma}{1-\alpha-\beta}\right) < 1$$

In the same way, we have $d(x_{n-1}, x_n) \le h\ d(x_{n-2}, x_{n-1})$.

By (2), we get $d(x_n, x_{n+1}) \le h^2\ d(x_{n-2}, x_{n-1})$ Continue this process , we get in general $d(x_n, x_{n+1}) \le h^n\ d(x_1, x_0)$. Since $0 \le h < 1$ as $n \to \infty$, $h^n \to 0$. Hence $\{x_n\}$ is a dq– cauchy sequence in X . Thus $\{x_n\}$ dislocated quasi converges to some u in X . Since T is continuous we have T(u) = lim T(x_n) = lim x_{n+1} = u .Thus u is a fixed point T.

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Now, $d(Tx^*, Ty^*) \le \alpha \frac{d(y^*, Ty^*)[1+d(x^*, Tx^*)]}{1+d(x^*, y^*)} + \beta\left(\frac{d(y^*, Tx^*) + d(x^*, Ty^*)}{1+d(y^*, Ty^*)\ d(y^*, Tx^*)}\right) + \gamma d(x^*, y^*)$ .....(3)

$$d(x^*, y^*) \le \alpha \frac{d(y^*, y^*)[1+d(x^*, x^*)]}{1+d(x^*, y^*)} + \beta\left(\frac{d(y^*, x^*) + d(x^*, y^*)}{1+d(y^*, y^*)\ d(y^*, x^*)}\right) + \gamma\, d(x^*, y^*)$$

$$d(x^*, y^*) \le 2\beta d(x^*, y^*) + \gamma d(x^*, y^*)$$

$$d(x^*, y^*) \le (2\beta+\gamma) d(x^*, y^*)$$

This is true only when d(x*, y*)=0. Similarly d(y*, x*)=0. Hence d(x*, y*)= d(y*, x*)=0 and so x* = y* . Hence T has a unique fixed point.

Theorem 3.3: Let (X , d) be a complete dislocated quasi metric space .Let T be a continuous mapping from X to X satisfying the following condition

$$d(Tx, Ty)) \le \frac{\alpha\, d(y, Ty)\, d(x, Tx)}{d(x, y)} + \beta\left(\frac{d(y, Tx) + d(x, Ty)}{1+d(y, Ty)\ d(y, Tx)}\right) + \gamma\ d(x, y) \quad .....(1)$$

for all $x, y \in X$, $\alpha, \beta, \gamma > 0$ and $\alpha + 2\beta + \gamma < 1$. Then T has a unique fixed point.

Proof: Let { x_n} be a sequence in X , defined as follows
Let $x_0 \in X$, $Tx_0 = x_1$, $Tx_1 = x_2$,............... , $Tx_n = x_{n+1}$.
Consider

$$d(x_n, x_{n+1}) = d(Tx_{n-1}, Tx_n)$$

$$\le \frac{\alpha\ d(x_n, Tx_n) d(x_{n-1}, Tx_{n-1})}{d(x_{n-1}, x_n)} + \beta\left(\frac{d(x_n, Tx_{n-1}) + d(x_{n-1}, Tx_n)}{1+d(x_n, Tx_n)\, d(x_n, Tx_{n-1})}\right) + \gamma\ d(x_{n-1}, x_n)$$

$$\le \frac{\alpha\ d(x_n, x_{n+1}) d(x_{n-1}, x_n)}{d(x_{n-1}, x_n)} + \beta\left(\frac{d(x_n, x_n) + d(x_{n-1}, x_{n+1})}{1+d(x_n, x_{n+1})\ d(x_n, x_n)}\right) + \gamma\ d(x_{n-1}, x_n)$$

$$\le \alpha\ d(x_n, x_{n+1}) + \beta\ d(x_{n-1}, x_{n+1}) + \gamma\ d(x_{n-1}, x_n)$$

$$(1-\alpha-\beta)\, d(x_n, x_{n+1}) \le (\beta+\gamma)\, d(x_{n-1}, x_n)$$

$$d(x_n, x_{n+1}) \le \left(\frac{\beta+\gamma}{1-\alpha-\beta}\right) d(x_{n-1}, x_n)$$

$$d(x_n, x_{n+1}) \le h\ d(x_{n-1}, x_n) \ldots\ldots(2) \quad where \quad h = \left(\frac{\beta+\gamma}{1-\alpha-\beta}\right) < 1$$

In the same way, we have $d(x_{n-1}, x_n) \le h\ d(x_{n-2}, x_{n-1})$.

By (2), we get $d(x_n, x_{n+1}) \le h^2\ d(x_{n-2}, x_{n-1})$ Continue this process , we get in general $d(x_n, x_{n+1}) \le h^n\ d(x_1, x_0)$. Since $0 \le h < 1$ as $n \to \infty$, $h^n \to 0$. Hence $\{x_n\}$ is a dq– cauchy sequence in X . Thus { x_n} dislocated quasi converges to some u in X . Since T is continuous we have T(u) = lim T(x_n) = lim x_{n+1} = u .Thus u is a fixed point T.

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$$d(x^*, y^*) \le \alpha \frac{d(y^*, y^*)\, d(x^*, x^*)}{d(x^*, y^*)} + \beta\left(\frac{d(y^*, x^*) + d(x^*, y^*)}{1 + d(y^*, y^*)\; d(y^*, x^*)}\right) + \gamma d(x^*, y^*)$$

$$d(x^*, y^*) \le 2\beta d(x^*, y^*) + \gamma d(x^*, y^*)$$

$$d(x^*, y^*) \le (2\beta + \gamma) d(x^*, y^*)$$

This is true only when d(x*, y*)=0. Similarly d(y*, x*)=0. Hence d(x*, y*)= d(y*, x*)=0 and so x* = y* . Hence T has a unique fixed point.

Theorem 3.4: Let (X , d) be a complete dislocated quasi metric space .Let T be a continuous mapping from X to X satisfying the following condition

$$d(Tx, Ty) \le \alpha\left(\frac{d(y, Tx) + d(x, Ty)}{d(x, y) + d(y, Ty)}\right) d(y, Ty) + \beta\left(\frac{d(y, Tx) + d(x, Ty)}{1 + d(y, Ty)\, d(y, Tx)}\right) + \gamma\, d(x, y) \quad .....(1)$$

for all $x, y \in X$, $\alpha, \beta, \gamma > 0$ *and* $\alpha + 2\beta + \gamma < 1$. Then T has a unique fixed point.

Proof: Let { x_n} be a sequence in X , defined as follows
Let $x_0 \in X$, $Tx_0 = x_1$, $Tx_1 = x_2$,............... , $Tx_n = x_{n+1}$.
Consider

$$d(x_n, x_{n+1}) = d(Tx_{n-1}, Tx_n)$$

$$\le \alpha\left(\frac{d(x_n, Tx_{n-1}) + d(x_{n-1}, Tx_n)}{d(x_{n-1}, x_n) + d(x_n, Tx_n)}\right) d(x_n, Tx_n) + \beta\left(\frac{d(x_n, Tx_{n-1}) + d(x_{n-1}, Tx_n)}{1 + d(x_n, Tx_n)\, d(x_n, Tx_{n-1})}\right) + \gamma\, d(x_{n-1}, x_n)$$

$$\le \alpha\left(\frac{d(x_n, x_n) + d(x_{n-1}, x_{n+1})}{d(x_{n-1}, x_n) + d(x_n, x_{n+1})}\right) d(x_n, x_{n+1}) + \beta\left(\frac{d(x_n, x_n) + d(x_{n-1}, x_{n+1})}{1 + d(x_n, x_{n+1})\, d(x_n, x_n)}\right) + \gamma\, d(x_{n-1}, x_n)$$

$$\le \alpha\, d(x_n, x_{n+1}) + \beta\, d(x_{n-1}, x_{n+1}) + \gamma\, d(x_{n-1}, x_n)$$

$$(1 - \alpha - \beta)\, d(x_n, x_{n+1}) \le (\beta + \gamma)\, d(x_{n-1}, x_n)$$

$$d(x_n, x_{n+1}) \le \left(\frac{\beta + \gamma}{1 - \alpha - \beta}\right) d(x_{n-1}, x_n)$$

$d(x_n, x_{n+1}) \le h\; d(x_{n-1}, x_n)$.......(2) *where* $h = \left(\dfrac{\beta + \gamma}{1 - \alpha - \beta}\right) < 1$

In the same way, we have $d(x_{n-1}, x_n) \le h\; d(x_{n-2}, x_{n-1})$.

By (2), we get $d(x_n, x_{n+1}) \le h^2\; d(x_{n-2}, x_{n-1})$ Continue this process , we get in general $d(x_n, x_{n+1}) \le h^n\; d(x_1, x_0)$. *Since* $0 \le h < 1$ *as* $n \to \infty$, $h^n \to 0$. Hence $\{x_n\}$ is a dq– cauchy sequence in X . Thus { x_n} dislocated quasi converges to some u in X . Since T is continuous we have T(u) = lim T(x_n) = lim x_{n+1} = u .Thus u is a fixed point T.

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Now, $d(Tx^*, Ty^*) \le \alpha\left(\dfrac{d(y^*, Tx^*) + d(x^*, Ty^*)}{d(x^*, y^*) + d(y^*, Ty^*)}\right) d(y^*, Ty^*) + \beta\left(\dfrac{d(y^*, Tx^*) + d(x^*, Ty^*)}{1 + d(y^*, Ty^*)\; d(y^*, Tx^*)}\right) + \gamma d(x^*, y^*)$ .....(3)

$$d(x^*, y^*) \le \alpha\left(\frac{d(y^*, x^*) + d(x^*, y^*)}{d(x^*, y^*) + d(y^*, y^*)}\right) d(y^*, y^*) + \beta\left(\frac{d(y^*, x^*) + d(x^*, y^*)}{1 + d(y^*, y^*)\; d(y^*, x^*)}\right) + \gamma d(x^*, y^*)$$

$$d(x^*, y^*) \le 2\beta d(x^*, y^*) + \gamma d(x^*, y^*)$$

$$d(x^*, y^*) \le (2\beta + \gamma) d(x^*, y^*)$$

This is true only when d(x*, y*)=0. Similarly d(y*, x*)=0. Hence d(x*, y*) = d(y*, x*)=0 and so x* = y* . Hence T has a unique fixed point.

Theorem 3.5: Let (X , d) be a complete dislocated quasi metric space .Let T be a continuous mapping from X to X satisfying the following condition

$$d(Tx, Ty)) \le \alpha\left(\frac{d(x,Ty)\ d(y,Ty)}{d(x,y)+d(y,Ty)}\right)+\beta\left(\frac{d(y,Tx)+d(x,Ty)}{1+d(y,Ty)\ d(y,Tx)}\right)+\gamma\ d(x,y) \quad .....(1)$$

for all $x, y \in X$, $\alpha, \beta, \gamma > 0$ *and* $\alpha + 2\beta + \gamma < 1$. Then T has a unique fixed point.

Proof: Let $\{x_n\}$ be a sequence in X , defined as follows
Let $x_0 \in X$, $Tx_0 = x_1$, $Tx_1 = x_2$,............... , $Tx_n = x_{n+1}$.
Consider

$$d(x_n, x_{n+1}) = d(Tx_{n-1}, Tx_n)$$

$$\le \alpha\left(\frac{d(x_{n-1},Tx_n)\ d(x_n,Tx_n)}{d(x_{n-1},x_n)+d(x_n,Tx_n)}\right)+\beta\left(\frac{d(x_n,Tx_{n-1})+d(x_{n-1},Tx_n)}{1+d(x_n,Tx_n)\,d(x_n,Tx_{n-1})}\right)+\gamma\ d(x_{n-1},x_n)$$

$$\le \alpha\left(\frac{d(x_{n-1},x_{n+1})\ d(x_n,x_{n+1})}{d(x_{n-1},x_n)+d(x_n,x_{n+1})}\right)+\beta\left(\frac{d(x_n,x_n)+d(x_{n-1},x_{n+1})}{1+d(x_n,x_{n+1})\ d(x_n,x_n)}\right)+\gamma\ d(x_{n-1},x_n)$$

$$\le \alpha\ d(x_n,x_{n+1})+\beta\ d(x_{n-1},x_{n+1})+\gamma\ d(x_{n-1},x_n)$$

$$(1-\alpha-\beta)\ d(x_n,x_{n+1}) \le (\beta+\gamma)\ d(x_{n-1},x_n)$$

$$d(x_n,x_{n+1}) \le \left(\frac{\beta+\gamma}{1-\alpha-\beta}\right) d(x_{n-1},x_n)$$

$$d(x_n,x_{n+1}) \le h\ d(x_{n-1},x_n) ....(2) \qquad \textit{where} \qquad h = \left(\frac{\beta+\gamma}{1-\alpha-\beta}\right) < 1$$

In the same way, we have $d(x_{n-1},x_n) \le h\ d(x_{n-2},x_{n-1})$.

By (2), we get $d(x_n,x_{n+1}) \le h^2\ d(x_{n-2},x_{n-1})$ Continue this process, we get in general $d(x_n,x_{n+1}) \le h^n\ d(x_1,x_0)$. *Since* $0 \le h < 1$ *as* $n \to \infty$, $h^n \to 0$. Hence $\{x_n\}$ is a dq– cauchy sequence in X . Thus $\{x_n\}$ dislocated quasi converges to some u in X . Since T is continuous we have T(u) = lim T(x_n) = lim x_{n+1} = u .Thus u is a fixed point T.

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Now, $$d(Tx^*, Ty^*) \le \alpha\left(\frac{d(x^*,Ty^*)\ d(y^*,Ty^*)}{d(x^*,y^*)+d(y^*,Ty^*)}\right)+\beta\left(\frac{d(y^*,Tx^*)+d(x^*,Ty^*)}{1+d(y^*,Ty^*)\ d(y^*,Tx^*)}\right)+\gamma d(x^*,y^*) \quad .....(3)$$

$$d(x^*,y^*) \le \alpha\left(\frac{d(x^*,y^*)\ d(y^*,y^*)}{d(x^*,y^*)+d(y^*,y^*)}\right)+\beta\left(\frac{d(y^*,x^*)+d(x^*,y^*)}{1+d(y^*,y^*)\ d(y^*,x^*)}\right)+\gamma d(x^*,y^*)$$

$$d(x^*,y^*) \le 2\beta d(x^*,y^*)+\gamma d(x^*,y^*)$$

$$d(x^*,y^*) \le (2\beta+\gamma) d(x^*,y^*)$$

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