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CONTRACTIVE MAPPINGS AND COMMON FIXED POINT THEOREMS IN INTUITIONISTIC FUZZY METRIC SPACES

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Abstract. This paper deals with some issues of common fixed point theory involving two different types of intuitionistic fuzzy contractive mappings. Intuitionistic fuzzy Jungck's common fixed point theorem (see, [1]) with respect to contraction defined in [8] and intuitionistic fuzzy Pant's common fixed point theorem (see, [2]) for ψ-ϕ weakly commuting mappings are proved.

Key Words: Intuitionistic fuzzy metric space, contractive mappings, commutative mappings, weakly commuting mappings, common fixed point.

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1. Introduction

The concept of intuitionistic fuzzy set as a generalization of fuzzy set [13] was introduced by Atansov [12]. George and Veeramani [5] have modified the definition of fuzzy metric which is introduced by Kramosil and Michalek [10].
Sessa [3] introduce a generalization of commutativity called weak commutativity. Further, Jungck [1] introduced more generalized commutativity which is called compatibility in metric space. He also proved

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common fixed point theorems. Pant [2] proved common fixed point theorems for non-commuting mappings.
In this paper, we prove the intuitionistic fuzzy version of two common fixed point theorems, namely; Jungck's and Pant's theorems for two generalized contractive mappings.

2. Preliminaries

We quote some definitions and statements of a few theorems which will be needed in the sequel.

Definition 2.1. [11] A binary operation $* : [0,1] \times [0,1] \to [0,1]$ is continuous t-norm if $*$, satisfies the following conditions:
(i) $*$ is commutative and associative,
(ii) $*$ is continuous,
(iii) $a * 1 = a$ for every $a \in [0,1]$,
(Iiv) $a * b \leq c * d$ whenever $a \leq c$, $b \leq d$ and $a, b, c, d \in [0,1]$.

A few examples of continuous t-norms are $a * b = ab$, $a * b = \min\{a, b\}$, $a * b = \max\{a + b - 1, 0\}$.

Definition 2.2. [11]. A binary operation $\diamond : [0,1] \times [0,1] \to [0,1]$, is continuous t-conorm if $\diamond$ satisfies the following conditions:
(i) $\diamond$ is commutative and associative,
(ii) $\diamond$ is continuous,
(iii) $a \diamond 0 = a$ for every $a \in [0,1]$,
(iv) $a \diamond b \leq c \diamond d$ whenever $a \leq c$, $b \leq d$ and $a, b, c, d \in [0,1]$.

A few examples of continuous t-conorms are $a \diamond b = a + b - ab, a \diamond b = \max\{a, b\}, a \diamond b = \min\{a + b, 1\}$.

Definition 2.3. [4] A 5-tuple $(X, \mu, \nu, *, \diamond)$ is said to be an intuitionistic fuzzy metric space if X is an arbitrary set, $*$ is a continuous t-norm, $\diamond$ is a continuous t-conorm, μ and ν are fuzzy sets on $X^2 \times (0, \infty)$ and μ denotes the degree of nearness, ν denotes the degree of non-nearness between x and y relative to t satisfying the following conditions: for all

$x, y, z \in X$, $s, t > 0$,
(i) $\mu(x,y,t) + \nu(x,y,t) \leq 1$
(ii) $\mu(x,y,t) > 0$;
(iii) $\mu(x,y,t) = 1$ if and only if $x = y$;
(iv) $\mu(x,y,t) = \mu(y,x,t)$;
(v) $\mu(x,z,t+s) \geq \mu(x,y,t) * \mu(y,z,s)$;
(vi) $\mu(x,y,\cdot) : (0,\infty) \to (0,1]$ is continuous;
(vii) $\nu(x,y,t) > 0$;
$(viii)$ $\nu(x,y,t) = 0$ if and only if $x = y$;
(ix) $\nu(x,y,t) = \nu(y,x,t)$;
(x) $\nu(x,z,t+s) \leq \nu(x,y,t) \diamond \nu(y,z,s)$;
(xi) $\nu(x,y,\cdot) : (0,\infty) \to (0,1]$ is continuous.

Definition 2.4. [7] Let Ψ be the class of all mappings $\psi : [0,1] \to [0,1]$ such that ψ is continuous, non-increasing and $\psi(t) < t$, $\forall\, t \in (0,1)$. Let Φ be the class of all mappings $\phi : [0,1] \to [0,1]$ such that ϕ is continuous, non-decreasing and $\phi(t) > t$, $\forall\, t \in (0,1)$. Let $(X, \mu, \nu, *, \diamond)$ be an intuitionistic fuzzy metric space and $\psi \in \Psi$ and $\phi \in \Phi$. A mapping $f : X \to X$ is called an intuitionistic fuzzy ψ-ϕ-contractive mapping if the following implications hold:

$$\mu(x,y,t) > 0 \;\Rightarrow\; \psi\left(\mu\left(f(x), f(y), t\right)\right) \geq \mu(x,y,t)$$

$$\nu(x,y,t) < 1 \;\Rightarrow\; \phi\left(\nu\left(f(x), f(y), t\right)\right) \leq \nu(x,y,t).$$

Definition 2.5. [8] Let (X, A) be an intuitionistic fuzzy metric space and $T : X \to X$. T is said to be TS-intuitionistic fuzzy contractive mapping if the following conditions hold for $k \in (0,1)$

$$k\, \mu(T(x), T(y), t) \geq \mu(x,y,t)$$

and

$$\frac{1}{k}\, \nu(T(x), T(y), t) \leq \nu(x,y,t), \quad t > 0\,.$$

Definition 2.6. [9] Let f and g be two mappings from a metric space (X, d) into itself. The mappings f and g are said to be weakly commuting if

$$d\,(\,f(g(x)),\,g(f(x)))\,\leq\,d\,(f(x)\,,\,g(x))\ \ ,\forall\,x\in\,X\,.$$

3. Common fixed point theorems for commuting mappings

Theorem 3.1. *Let $(X, \mu, \nu, *, \diamond)$ be a complete intuitionistic fuzzy metric space and $f, g : X \to X$ be such that*
(i) $g(X) \subseteq f(X)$,
(ii) f is continuous on X,
(iii) there exists $k \in (0,1)$ such that for all $x, y \in X$ and $t > 0$,

$$k\,\mu(g(x), g(y), t) \geq \mu(f(x), f(y), t)$$
$$\frac{1}{k}\,\nu(g(x), g(y), t) \leq \nu(f(x), f(y), t), \quad t > 0\,.$$

Then f and g have a unique common fixed point in X provided f, g commute on X.

Proof. Let $x_0 \in X$. By (i), we can find $x_1 \in X$ such that $f(x_1) = g(x_0)$. So, we can define a sequence $\{x_n\}_n$ in X such that $f(x_n) = g(x_{n-1})$. Now,

$$\begin{aligned} k^n\,\mu\,(f(x_n,\,f(x_{n+1}),\,t)) &= k^n\,\mu\,(g(x_{n-1},\,g(x_n),\,t)) \\ &\geq k^{n-1}\,(k\,\mu\,(g(x_{n-1},\,g(x_n),\,t))) \\ &= k^{n-1}\,\mu\,(f(x_{n-1},\,f(x_n),\,t)) \\ &= k^{n-2}\,(\,k\mu\,(g(x_{n-2},\,g(x_{n-1}),\,t))) \\ &\geq k^{n-2}\,\mu\,(f(x_{n-2},\,f(x_{n-1}),\,t)) \\ &\geq \cdots \geq \mu\,(f(x_0), f(x_1), t) \end{aligned}$$

and

$$\frac{1}{k^n}\nu\,(f(x_n), f(x_{n+1}), t)\,\leq\,\nu\,(f(x_0), f(x_1), t)\,.$$

Therefore

$$\mu\,(f(x_n), f(x_{n+p}), t)$$

$$\geq\,\mu\left(f(x_n), f(x_{n+1}), \frac{t}{p}\right)\,*\,\mu\left(f(x_{n+1}), f(x_{n+2}), \frac{t}{p}\right)*$$

$$\cdots * \ \mu\left(f(x_{n+p-1}), f(x_{n+p}), \tfrac{t}{p}\right)$$

$$= \tfrac{1}{k^n}\, k^n\, \mu\left(f(x_n), f(x_{n+1}), \tfrac{t}{p}\right) * \tfrac{1}{k^{n+1}}\, k^{n+1}\, \mu\left(f(x_{n+1}), f(x_{n+2}), \tfrac{t}{p}\right) *$$

$$\cdots * \tfrac{1}{k^{n+p-1}}\, k^{n+p-1}\, \mu\left(f(x_{n+p-1}), f(x_{n+p}), \tfrac{t}{p}\right)$$

$$= \tfrac{1}{k^n}\, \mu\left(f(x_0), f(x_1), t_1\right) * \tfrac{1}{k^{n+1}}\, \mu\left(f(x_0), f(x_1), t_1\right) *$$

$$\cdots * \tfrac{1}{k^{n+p-1}}\, \mu\left(f(x_0), f(x_1), t_1\right), \text{ where } t_1 = \tfrac{t}{p}.$$

$$\geq \tfrac{1}{k^n}\, \mu\left(f(x_0), f(x_1), t_1\right), \text{ since } a \geq c \Rightarrow a * c \geq c * c \geq c.$$

Thus we have

$$\mu\left(f(x_n), f(x_{n+p}), t\right) \geq \frac{1}{k^n}\, \mu\left(f(x_0), f(x_1), t_1\right).$$

Similarly we have

$$\nu\left(f(x_n), f(x_{n+p}), t\right) \geq k^n\, \nu\left(f(x_0), f(x_1), t_1\right).$$

Now

$$\lim_{n \to \infty} \mu\left(f(x_n), f(x_{n+p}), t\right) \geq \lim_{n \to \infty} \frac{1}{k^n}\, \mu\left(f(x_0), f(x_1), t_1\right) \geq 1.$$

$$\lim_{n \to \infty} \nu\left(f(x_n), f(x_{n+p}), t\right) \leq \lim_{n \to \infty} k^n\, \nu\left(f(x_0), f(x_1), t_1\right) \leq 0.$$

Therefore

$$\lim_{n \to \infty} \mu\left(f(x_n), f(x_{n+p}), t\right) = 1, \quad \lim_{n \to \infty} \nu\left(f(x_n), f(x_{n+p}), t\right) = 0.$$

$$\Rightarrow \{f(x_n)\}_n \text{ is a sequence in } (X, \mu, \nu, *, \diamond).$$

$$\Rightarrow \exists\, y \in X \text{ such that } f(x_n) \to y \text{ as } n \to \infty \text{ in } (X, \mu, \nu, *, \diamond).$$

Since $g(x_{n+1}) = f(x_n)$, it follows that $g(x_n) \to y$ as $n \to \infty$ in $(X, \mu, \nu, *, \diamond)$.

The continuity of f implies the continuity of g by (iii). Therefore, $\{g(f(x_n))\}_n$ converges to $g(y)$ in $(X, \mu, \nu, *, \diamond)$. However, since f and g commute on X, $g(f(x_n))$ and $f(g(x_n))$ are so and $f(g(x_n)) \to f(y)$ as $n \to \infty$. Since the limits are unique, $f(y) = g(y)$, which implies that $f(f(y)) = f(g(y))$.

Now $\mu(g(y), g(g(y)), t) = \frac{1}{k}\, k\, \mu(g(y), g(g(y)), t) \geq \frac{1}{k}\, \mu(f(y), f(g(y)), t) =$

$\frac{1}{k}\,\mu(f(y), g(f(y)), t) \;=\; \frac{1}{k}\,\mu(g(y), g(g(y)), t) \;\geq\; \cdots \;\geq\; \frac{1}{k^n}\,\mu(g(y), g(g(y)), t)$.
Similarly, $\mu(g(y), g(g(y)), t) \;\leq\; k^n\,\mu(g(y), g(g(y)), t)$.
Therefore, $g(y) = g(g(y))$ and hence $g(y) = g(g(y)) = g(f(y)) = f(g(y)) \;\Rightarrow\; g(y)$ is a common fixed point of f and g.
If y and z are two common fixed points of f and g then
$1 \geq \mu(y, z, t) = \mu(g(y), g(z), t) = \frac{1}{k}\,k\,\mu(g(y), g(z), t) \geq \frac{1}{k}\,\mu(f(y), f(z), t) = \mu(y, z, t) = \frac{1}{k^2}\,k\,\mu(g(y), g(z), t) \geq \frac{1}{k^2}\mu(f(y), f(z), t) = \cdots \geq \frac{1}{k^n}\mu(y, z, t) \geq 1$.
Similarly, $0 \;\leq\; \nu(y, z, t) \;\leq\; 0$. Therefore, $\mu(y, z, t) = 1$, $\nu(y, z, t) = 0$. Hence $y = z$. This completes the proof. □

4. Common fixed point theorems for Ψ-Φ-weakly commuting mappings

Definition 4.1. Let f and g be self mappings of an intuitionistic fuzzy metric space $(X, \mu, \nu, *, \diamond)$. The mappings f and g are said to be Ψ-Φ-weakly commuting if

$$\psi\,(\mu(f(g(x)), g(f(x)), t)) \geq \mu(f(x), g(x), t),$$

$$\phi\,(\nu(f(g(x)), g(f(x)), t)) \leq \nu(f(x), g(x), t).$$

Theorem 4.2. *Let $(X, \mu, \nu, *, \diamond)$ be a complete intuitionistic fuzzy metric space and f, g be intuitionistic fuzzy Ψ-Φ-weakly commuting self mappings of X satisfying the following conditions*
(i) $f(X) \subset g(x)$,
(ii) f or g is continuous,
(iii) for all $x, y \in X$ and $0 < t < 1$

$$\mu(f(x), f(y), t) \;\geq\; \phi\,(\mu(g(x), g(y), t))\,,$$

$$\nu(f(x), f(y), t) \;\leq\; \psi\,(\nu(g(x), g(y), t))\,.$$

(iv) $\lim\limits_{n \to \infty} x_n = x$ and $\lim\limits_{n \to \infty} y_n = y$ implies $\lim\limits_{n \to \infty} \mu(x_n, y_n, t) = \mu(x, y, t)$ and $\lim\limits_{n \to \infty} \nu(x_n, y_n, t) = \mu(x, y, t)$ then f and g have unique common fixed point in X.

Proof. Let $x_0 \in X$. Choose a point x_1 in X such that $f(x_0) = g(x_1)$. In general, we can choose x_{n+1} such that $f(x_n) = g(x_{n+1})$ for all $n \geq 0$. Then for all $t > 0$:
$\mu\left(f(x_n), f(x_{n+1}, t)\right) \geq \phi(\mu\left(g(x_n), g(x_{n+1}, t)\right)) = \phi(\mu\left(f(x_{n-1}), f(x_n, t)\right))$
$> \mu\left(f(x_n), f(x_{n+1}, t)\right)$,
$\nu\left(f(x_n), f(x_{n+1}, t)\right) \leq \psi(\nu\left(g(x_n), g(x_{n+1}, t)\right)) = \psi(\nu\left(f(x_{n-1}), f(x_n, t)\right))$
$< \nu\left(f(x_n), f(x_{n+1}, t)\right)$.
Thus $\{\mu\left(f(x_n), f(x_{n+1}, t)\right)\}_n$ is an increasing sequence and $\{\nu\left(f(x_n), f(x_{n+1}, t)\right)\}_n$ is a decreasing sequence of positive real numbers in [0,1]. Therefore they converges to the limits $l \leq 1$ and $l' \geq 0$ respectively.
Now we claim that $l = 1$ and $l' = 0$. For $l < 1$, we have $l \geq \phi(l) > l$, a contradiction. So, $l = 1$. Similarly, for $l' > 0$ we have $l' \leq \psi(l') < l'$, a contradiction. So, $l' = 0$.
Now for any positive integer p and $t > 0$, we have

$$\begin{aligned}
&\mu\left(f(x_n), f(x_{n+p}), t\right)\\
&\geq \mu\left(f(x_n), f(x_{n+1}), \tfrac{t}{p}\right) * \mu\left(f(x_{n+1}), f(x_{n+2}), \tfrac{t}{p}\right) * \\
&\qquad \cdots * \mu\left(f(x_{n+p-1}), f(x_{n+p}), \tfrac{t}{p}\right)\\
&\geq \mu\left(f(x_n), f(x_{n+1}), \tfrac{t}{p}\right) * \mu\left(f(x_n), f(x_{n+1}), \tfrac{t}{p}\right) * \\
&\qquad \cdots * \mu\left(f(x_n), f(x_{n+1}), \tfrac{t}{p}\right)
\end{aligned}$$

and

$$\begin{aligned}
&\nu\left(f(x_n), f(x_{n+p}), t\right)\\
&\leq \nu\left(f(x_n), f(x_{n+1}), \tfrac{t}{p}\right) \diamond \nu\left(f(x_{n+1}), f(x_{n+2}), \tfrac{t}{p}\right) \diamond \\
&\qquad \cdots \diamond \nu\left(f(x_{n+p-1}), f(x_{n+p}), \tfrac{t}{p}\right)\\
&\leq \nu\left(f(x_n), f(x_{n+1}), \tfrac{t}{p}\right) \diamond \nu\left(f(x_n), f(x_{n+1}), \tfrac{t}{p}\right) \diamond \\
&\qquad \cdots \diamond \nu\left(f(x_n), f(x_{n+1}), \tfrac{t}{p}\right).
\end{aligned}$$

Since we have

$$\lim_{n \to \infty} \mu\left(f(x_n), f(x_{n+1}), \frac{t}{p}\right) = 1\,, \quad \lim_{n \to \infty} \nu\left(f(x_n), f(x_{n+1}), \frac{t}{p}\right) = 0.$$

It follows that

$$\lim_{n \to \infty} \mu\left(f(x_n), f(x_{n+p}), t\right) \geq 1 * 1 * \cdots\cdots * 1 \geq 1\,,$$
$$\lim_{n \to \infty} \nu\left(f(x_n), f(x_{n+p}), t\right) \leq 0 \diamond 0 \diamond \cdots\cdots \diamond 0 \leq 0\,.$$

Therefore, $\lim_{n\to\infty} \mu\left(f(x_n), f(x_{n+p}), t\right) = 1$ and $\lim_{n\to\infty} \nu\left(f(x_n), f(x_{n+p}), t\right) = 0$. Thus, $\{f(x_n)\}_n$ is a Cauchy sequence and since X is complete, $\{f(x_n)\}_n$ converges to a point $z \in X$. Also, $\{g(x_n)\}_n$ converges to z.

Suppose that, by (ii), f is uniformly intuitionistic fuzzy continuous. Then $\lim_{n \to \infty} f(f(x_n)) = f(z)$ and $\lim_{n \to \infty} f(g(x_n)) = f(z)$. Further, since f and g are ψ-ϕ weakly commuting, we have

$$\psi\left(\mu(f(g(x)), g(f(x)), t)\right) \geq \mu(f(x), g(x), t),$$
$$\phi\left(\nu(f(g(x)), g(f(x)), t)\right) \leq \nu(f(x), g(x), t).$$

Letting $n \to \infty$ in the inequality and by (iv), we have $\lim_{n \to \infty} g(f(x_n)) = f(z)$.

Now we prove that $z = f(z)$. If possible let $z \neq f(z)$. Then there exists $t > 0$ such that $\mu(z, f(z), t) < 1$ and $\nu(z, f(z), t) > 0$. From (iii) we have

$$\mu(f(x_n), f(f(x_n)), t) \geq \phi(\mu(g(x_n), g(f(x_n)), t)),$$
$$\nu(f(x_n), f(f(x_n)), t) \geq \psi(\nu(g(x_n), g(f(x_n)), t)).$$

Taking limit as $n \to \infty$ we have

$$\mu(z, f(z), t) \geq \phi(\mu(z, f(z), t)) > \mu(z, f(z), t),$$
$$\nu(z, f(z), t) \leq \psi(\nu(z, f(z), t)) < \nu(z, f(z), t),$$

which are contradictions. Therefore $z = f(z)$.

By (i), we can find a point $z_1 \in X$ such that $z = f(z) = g(z_1)$. Now, it follows that

$$\mu(f(f(x_n)), f(z_1), t) \geq \phi(\mu(g(f(x_n)), g(z_1), t)),$$

$$\nu(f(f(x_n)), f(z_1), t) \leq \psi(\nu(g(f(x_n)), g(z_1), t)).$$

Taking limit as $n \to \infty$ we have

$$\mu(f(z), f(z_1), t) \geq \phi(\mu(f(z), g(z_1), t)) = 1,$$

$$\nu(f(z), f(z_1), t) \leq \psi(\nu(f(z), g(z_1), t)) = 0,$$

since $\phi(1) = 1$ and $\psi(0) = 0$. This implies that $f(z) = f(z_1)$ i.e., $z = f(z) = f(z_1) = g(z_1)$. Also for any $t > 0$

$$\psi(\mu(f(z), g(z), t)) = \psi(\mu(f(g(z_1)), g(f(z_1)), t)) \geq \mu(f(z_1), g(z_1), t) = 1.$$

Therefore, $\psi(\mu(f(z), g(z), t)) = 1$ and hence $\mu(f(z), g(z), t) = 1$.

$$\phi(\nu(f(z), g(z), t)) = \phi(\nu(f(g(z_1)), g(f(z_1)), t)) \leq \mu(f(z_1), g(z_1), t) = 0.$$

Therefore, $\phi(\nu(f(z), g(z), t)) = 0$ and hence $\nu(f(z), g(z), t) = 0$. Which again implies that $f(z) = g(z)$. Therefore z is a common fixed point of f and g.

If x, y are fixed points of f then

$$\mu(f(x), f(y), t) = \mu(x, y, t) \leq \psi(\mu(f(x), f(y), t))$$

and

$$\nu(f(x), f(y), t) = \nu(x, y, t) \geq \phi(\nu(f(x), f(y), t)), \ \forall\, t > 0.$$

If $x \neq y$ then $\mu(x, y, s) < 1$ and $\nu(x, y, s) > 0$ for some $s > 0$ i.e., $0 < \mu(x, y, s) < 1$ and $0 < \nu(x, y, s) < 1$ hold, implying

$$\mu\left(f(x), f(y), s\right) \leq \psi(\mu\left(f(x), f(y), s\right)) < \mu(f(x), f(y), s)$$

and

$$\nu\left(f(x), f(y), s\right) \geq \phi(\nu\left(f(x), f(y), s\right)) > \nu(f(x), f(y), s)$$

which are contradictions. Thus $x = y$. This completes the proof. □

Example 4.3. *Let* $(X, \|\cdot\|)$ *be a normed linear space and consider* $a * b = ab$ *and* $a \diamond b = \min\{a+b, 1\}$. *Define* $\mu, \nu : V \times V \times \mathbb{R} \to [0,1]$ *by*

$$\mu(x,y,t) \;=\; \frac{t}{t+\|x-y\|}\;, \qquad \nu(x,y,t) \;=\; \frac{\|x-y\|}{t+\|x-y\|}$$

Then clearly $(V,\mu,\nu,*,\diamond)$ *is an intuitionistic fuzzy metric space.*
Define two self mappings f *and* g *on* X *by*

$$f(x)=1 \;\; and \;\; g(x) \;=\; \begin{cases} 1, & if\ x\ is\ a\ rational\ number \\ 0, & if\ x\ is\ an\ irrational\ number. \end{cases}$$

Then $f(X)\subset g(X)$, f *is continuous and* g *is discontinuous.*
Define $\psi(t) = t^2$ *and* $\phi(t) = \sqrt{t}$, *for* $t \in (0,1)$. *Then* $\psi(t) < t$ *and* $\phi(t) > t$ *and for all* $x,y\in X$

$$\mu\,(f(x),f(y),t) \geq \phi\,(\;\mu\,(g(x),g(y),t)\;)\,,$$
$$\nu\,(f(x),f(y),t) \leq \psi\,(\;\nu\,(g(x),g(y),t)\;)\,.$$

Also, f *and* g *are* ψ-ϕ *weakly commuting. Hence* 1 *is a common fixed point of* f *and* g.

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References

[1] G. Jungck, *Compatible mappings and common fixed points*, Internat. J. Math. Math. Sci., **9** (1986), 771–774.

[2] R. P. Pant, *Common fixed points of noncommuting mappings*, J. Math. Anal. Appl., **188** (1994), 436 – 440.

[3] S. Sessa, *On a weak commutativity condition of mappings in fixed point considerations*, Publ. Inst. Math., **32** (1982), 149–153.

[4] J. H. Park, *Intuitionistic fuzzy metric spaces*, Chaos, Solitons and Fractals, **22** (2004), 1039–1046.

[5] A. George and P. Veeramani, *On some results in fuzzy metric spaces*, Fuzzy Sets and Systems, **64** (1994), 395–399.

[6] D. Mihet, *Fuzzy ψ-contractive mappings in non-Archimedian fuzzy metric spaces*, Fuzzy Sets and Systems, **159** (2008), 739–744.

[7] B. Dinda, T. K. Samanta, I. H. Jebril, *Intuitionistic fuzzy Ψ-Φ-contractive mappings and fixed point theorems in non-Archimedean intuitionistic fuzzy metric spaces*, Preprint, arXiv:1102.2096 v1.

[8] T. K. Samanta, Sumit Mohinta, I. H. Jebril, *On fixed point theorems in intuitionistic fuzzy metric space*, Gen. Math. Notes, **3(2)** (2011), 1–12.

[9] B. Fisher and S. Sessa, *Two common fixed point theorems for weakly commuting mappings*, Period. Math. Hungar., **20** (1989), 207–218.

[10] O. Kramosil, J. Michalek, *Fuzzy metric and statistical metric spaces*, Kybernetica, **11** (1975), 326–334.

[11] B. Schweizer, A. Sklar, *Statistical metric space*, Pacific Journal of Mathematics, **10** (1960), 314–334.

[12] K. Atanassov, *Intuitionistic fuzzy sets*, Fuzzy Sets and Systems, **20** (1986), 87–96.

[13] L. A. Zadeh, *Fuzzy sets*, Information and Control, **8** (1965), 338–353.

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