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Survey Article

A short survey on interpolative contractions

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ABSTRACT. The aim of this manuscript is to collect recent publications that deal with the interpolative contractions in the fixed point theory. This short survey also aims to indicate the observed results to bring mind the possible other directions to enrich the literature of fixed point theory and its applications. This paper can be considered as a continuation, completion and extension of [54].

Keywords: Fixed point, metric space, interpolative contraction.

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1. INTRODUCTION

The concept of interpolative contractions was introduced by Karapınar in [45] based on Kannan contractions (see [43]), via interpolation notion. The statement of an interpolative Kannan type contraction is the following:

Definition 1.1. *Let (X, d) be a metric space. We say that the self-mapping $T : X \to X$ is an interpolative Kannan type contraction, if there exist a constant $\lambda \in [0, 1)$ and $\alpha \in (0, 1)$ such that*

$$d(Tx, Ty) \leq \lambda[d(x, Tx)]^{\alpha} \cdot [d(y, Ty)]^{1-\alpha} \tag{1.1}$$

for all $x, y \in X \setminus Fix\{T\}$, where $Fix\{T\} = \{x \in X | x \neq Tx\}$.

In [45] Karapınar proved the existence of a fixed point for interpolative Kannan contraction in complete metric spaces. Note that the uniqueness condition discussed and corrected in [49]:

Theorem 1.1 (Theorem 2.2 [45] and Theorem 2 [49])**.** *Let (X, d) be a complete metric space and $T : X \to X$ be an interpolative Kannan contraction. Then T has a fixed point.*

The novel concept sparked a great interest in the research community and opened numerous new research directions. This enthusiasm is evident from the high citation counts of the original paper, where interpolative contractions were introduced in various citation databases, underscoring its impact. For instance, [45] has been cited over 140 times in the Web of Science database, more than 160 times in Scopus database, and almost 200 times in Google Scholar database.

The current paper aims to collect in one place many of the new results related to interpolative contractions which emerged from the new idea from [45]. This collection can be a useful starting point for any researcher interested in interpolative contractions. Our paper aims to gather more recent results in the theory of interpolative contractions, besides the papers on the subject which appeared up to 2022, that are included in the comprehensive literature review from [54].

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2. Preliminaries

In this section, we collect some basic notions related to generalizations of metric spaces and some significant contractions in metric spaces. Also, we recall some notions about admissible mappings, as many generalizations arose from this concept. These notions are essential in following the results contained in the many research papers that involve interpolative contractions.

2.1. **Certain Generalizations of Metric Spaces.**

2.1.1. *b-Metric Spaces.*

Definition 2.2. *Let X be a nonempty set, $b \geq 1$ be a given real number and $d : X \times X \to [0, \infty)$ such that for all $x, y, z \in X$, the following conditions are satisfied:*

(b1) $d(x, y) = 0$ *if and only if* $x = y$,
(b2) $d(x, y) = d(y, x)$,
(b3) $d(x, z) \leq b[d(x, y) + d(y, z)]$.

Then b is called a b-metric and a triplet (X, d, b) is called a b-metric space.

2.1.2. *Partial Metric Spaces.*

Definition 2.3 (see [71])**.** *Let $p : X \times X \to [0, \infty)$ such that for each $x, y, w \in X$, we have:*

(P1) $x = y \Leftrightarrow p(x, x) = p(y, y) = p(x, y)$,
(P2) $p(x, x) \leq p(x, y)$,
(P3) $p(x, y) = p(y, x)$,
(P4) $p(x, y) \leq p(x, w) + p(w, y) - p(w, w)$.

Then p is called a partial distance and the pair (X, d) is called a partial metric space.

2.1.3. *Quasi-Metric Spaces.* A distance function $q : X \times X \to [0, \infty)$ is called a quasi-metric on X if:

(q1) $q(u, v) = 0 \Leftrightarrow u = v$,
(q2) $q(u, w) \leq q(u, v) + q(v, w)$, for all $u, v, w \in X$.

In addition, the pair (X, q) is called a quasi-metric space.

2.1.4. *Branciari Distance Space.*

Definition 2.4. *Let $d : X \times X \to [0, \infty)$ such that for all $x, y \in X$ and all distinct points $u, v \in X$, each distinct from x and y the following hold:*

(d1) $d(x, y) = 0$ *if and only if* $x = y$,
(d2) $d(x, y) = d(y, x)$,
(d3) $d(x, y) \leq d(x, u) + d(u, v) + d(v, y)$.

Then d is called a Branciari distance and the pair (X, d) is called a Branciari distance space.

2.2. **Significant Contractions.**

We recall some significant contractions which are essential in fixed point theory. These contractions are at the base of some interesting generalizations related to interpolative contractions. The first metric fixed point theorem was given by Banach [13]. We recall the Banach-Picard-Cacciopolli theorem, known as Banach's contraction mapping principle.

Theorem 2.2 (see [13])**.** *Let (X, d) be a complete metric space and $T : X \to X$ be a contraction mapping, i.e.,*

$$d(Tx, Ty) \leq \lambda d(x, y)$$

for all $x, y \in X$, where $\lambda \in [0, 1)$. Then T has a unique fixed point.

2.2.1. *Kannan Contractions.* One of the first extensions of Banach's contraction mapping principle was given by Kannan in [43], for mappings which are not necessarily continuous.

Theorem 2.3 (see [43]). *Let (X, d) be a complete metric space and $T : X \to X$ be a Kannan contraction mapping, i.e.,*

$$d(Tx, Ty) \le \lambda \left[d(x, Tx) + d(y, Ty)\right]$$

for all $x, y \in X$, where $\lambda \in \left[0, \frac{1}{2}\right)$. Then T has a unique fixed point.

2.2.2. *Chatterjea Contractions.* Another generalization for mappings which need not to be continuous is that of Chatterjea [16]:

Theorem 2.4 (see [16]). *Let (X, d) be a complete metric space and $T : X \to X$ be a Chatterjea contraction mapping, i.e.,*

$$d(Tx, Ty) \le \lambda \left[d(y, Tx) + d(x, Ty)\right]$$

for all $x, y \in X$, where $\lambda \in \left[0, \frac{1}{2}\right)$. Then T has a unique fixed point.

2.2.3. *Reich-Rus-Ćirić Contractions.* Another renowned result was proved independently by Rus, Reich, and Ćirić, see [86, 87, 88, 18].

Theorem 2.5. *Let (X, d) be a complete metric space and $T : X \to X$ be a Rus-Reich-Ćirić contraction mapping, that is,*

$$d(Tx, Ty) \le \lambda \left[d(x, y) + d(x, Tx) + d(y, Ty)\right]$$

for all $x, y \in X$, where $\lambda \in \left[0, \frac{1}{3}\right)$. Then T has a unique fixed point.

Notice that several variations of Rus-Reich-Ćirić contraction can be stated also as

$$d(Tx, Ty) \le ad(x, y) + bd(x, Tx) + cd(y, Ty),$$

where a, b, c are nonnegative real numbers such that $0 \le a + b + c < 1$. In what follows, we state the well-known Hardy-Rogers contraction.

2.2.4. *Hardy-Rogers Contractions.*

Theorem 2.6 (see [38]). *Let (X, d) be a complete metric space. Let $T : X \to X$ be a given mapping such that*

$$d(Tx, Ty) \le \alpha d(x, y) + \beta d(x, Tx) + \gamma d(y, Ty) + \delta \left[\frac{1}{2}(d(x, Ty) + d(y, Tx))\right]$$

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

2.2.5. *Meir-Keeler Contractions.* Another generalization of Banach's fixed point theorem was introduced by Meir and Keeler in [72] as follows:

Theorem 2.7 (see [72]). *Let (X, d) be a complete metric space and let T be a Meir-Keeler contraction on X, i.e., for every $s > 0$, there exists $\varepsilon > 0$ such that*

$$d(x, y) < s + \varepsilon \implies d(Tx, Ty) < s$$

for all $x, y \in X$. Then T has a unique fixed point.

2.2.6. *Geraghty Contractions.* In 1973, Geraghty introduced the class of functions $\mathcal{G}$ which denotes all functions $\beta : [0, \infty) \to [0, 1)$ which satisfy the condition:

$$\lim_{n\to\infty} \beta(t_n) = 1 \implies \lim_{n\to\infty} t_n = 0.$$

We recall the fixed point theorem associated to this class of functions:

Theorem 2.8 (see [36]). *Let (X, d) be a complete metric space and $T : X \to X$ be an operator. Suppose that there exists $\beta \in \mathcal{G}$ such that f satisfies the following inequality:*

$$d(Tx, Ty) \le \beta(d(x, y))d(x, y) \text{ for any } x, y \in X. \tag{2.2}$$

Then T has a unique fixed point in X.

2.2.7. *Jaggi Contractions.*

Theorem 2.9 (see [41]). *Let (X, d) be a complete metric space and $T : X \to X$ be a continuous map such that there exist $\alpha, \beta \in [0, 1)$ with $\alpha + \beta < 1$ such that:*

$$d(Tt, Ts) \le \alpha \frac{d(s, Ts)(1 + d(t, Tt))}{1 + d(t, s)} + \beta d(t, s)$$

holds for every distinct $t, s \in X$. Then T has a unique fixed point.

2.3. **Admissible Mappings.** Let Ψ be the family of functions $\psi : [0, \infty) \to [0, \infty)$ satisfying the following conditions:

- (Ψ_1) ψ is nondecreasing,
- (Ψ_2) there exist $k_0 \in \mathbb{N}$ and $a \in (0, 1)$ and a convergent series of nonnegative terms $\sum_{k=1}^{\infty} v_k$ such that

$$\psi^{k+1}(t) \le a\psi^k(t) + v_k$$

for $k \ge k_0$ and any $t \in [0, \infty)$.

Definition 2.5 (see [61]). *For a nonempty set X, let $T : X \to X$ and $\alpha : X \times X \to [0, \infty)$.*

(i) *(see [93]) We say that T is α-admissible if*

$$x, y \in X,\ \alpha(x, y) \ge 1 \Rightarrow \alpha(Tx, Ty) \ge 1.$$

(ii) *(see [44]) A self-mapping T is called triangular α-admissible if*
  (1) T is α-admissible and
  (2) $\alpha(x, y) \ge 1$ and $\alpha(y, z) \ge 1$ imply $\alpha(x, z) \ge 1$ for any $x, y, z \in X$.

(iii) *(see [11]) Let $S : X \to X$ be a mapping. We say that (T, S) is a generalized α-admissible pair if for all $x, y \in X$, we have*

$$\alpha(x, y) \ge 1 \Rightarrow \alpha(Tx, Sy) \ge 1 \text{ and } \alpha(STx, TSy) \ge 1.$$

(iv) *(see [82]) We say that T is α-orbital admissible if*

$$\alpha(x, Tx) \ge 1 \Rightarrow \alpha(Tx, T^2x) \ge 1.$$

Also, T is called triangular α-orbital admissible if T is α-orbital admissible and

$$\alpha(x, y) \ge 1 \text{ and } \alpha(y, Ty) \ge 1 \Rightarrow \alpha(x, Ty) \ge 1.$$

3. Interpolative-Kannan Contractions

In [28], Gaba and Karapınar introduced new results that refine inequality (1.1) by increasing the degrees of freedom for the exponents on the right-hand side within the context of standard metric spaces:

Theorem 3.10 (Theorem 2 from [28]). *Let (X, d) be a complete metric space and $T : X \to X$ be a (λ, α, β)-interpolative Kannan contraction, i.e. there exist $\lambda \in [0, 1)$, $\alpha, \beta \in (0, 1)$ such that $\alpha + \beta < 1$*

$$d(Tx, Ty) \leq \lambda [d(x, Tx)]^{\alpha} \cdot [d(y, Ty)]^{\beta} \tag{3.3}$$

for all $x, y \in X \setminus Fix\{T\}$. Then T has a fixed point in X.

In the same paper [28], results related to common fixed points for (λ, α, β)-interpolative Kannan contraction. Interpolative Kannan contractions were generalized in [1] to (a, b, α)-enriched interpolative Kannan type operator. In [1], there is proved the fixed point result for such operators, along with the study of the well-posedness, Ulam-Hyers stability and periodic point property of the operators introduced therein:

Theorem 3.11 (Theorem 2.4. from [1]). *Let $(X, \|\cdot\|)$ be a normed space and $T : X \to X$ be a (a, b, α)-enriched interpolative Kannan type operator, i.e. there exist $b \in [0, \infty)$, $a \in [0, 1)$ and $\alpha \in (0, 1)$ such that for all $x, y \in X$, we have*

$$\|b(x - y) + (Tx - Ty)\| \leq a \left(\|x - Tx\|^{\alpha} \|y - Ty\|^{1-\alpha} \right). \tag{3.4}$$

Then:

(1) $Fix(T) = \{x^*\}$,
(2) There exists a T_λ-orbital sequence $\{x_n\}_{n=0}^{\infty}$ around x_0, given by

$$x_{n+1} = (1 - \lambda)x_n + \lambda T x_n, \quad n \geq 0, \tag{3.5}$$

which converges to x^*, provided that for $x_0 \in X$, the T_λ-orbital subset $O(T_\lambda, x_0)$ (a sequence $\{x_n\}_{n=0}^{\infty}$ in X, given by $x_n = T^n x_0, \quad n = 1, 2, \ldots$, where x_0 is an initial guess in the domain of an operator T, is called a T-orbital sequence around x_0 and the collection of all such sequences is denoted by $O(T, x_0)$) is a complete subset of X, where $\lambda = \frac{1}{b+1}$.

These operators, where furthermore studied and generalized to MR-Kannan interpolative contractions in [7] with applications to the variational inequality problem, interpolative enriched cyclic Kannan contraction mappings in [8] with application to solve nonlinear integral equations.

Another direction of research is related to fractals based on interpolative Kannan contractions which was studied in [95]. However, the idea relies on the concept of K-iterated function systems from [94] where, as Van Dung et al proved in [102], the main results in the theory of K-iterated function systems, do not hold, which leaves these ideas of generalization as an open problem. More generalizations were obtained as follows:

- Fixed point results and common fixed point results in b-metric spaces, see [27],
- Results in T_0-quasi-metric spaces, see [29],
- Extensions to m-metric (see [10]) spaces, see [67],
- Results in metric spaces which are not necessarily complete, see [5],
- Results in bipolar metric spaces (see [79]), see [103],
- Cyclic contractions, see [21],
- Multivalued interpolative Kannan-type contraction, see [69],
- Enriched contractions, see [85].

4. Interpolative Hardy-Rogers Contractions

One of the first ideas that emerged from Karapınar's pioneering work is related to weakening the contractive condition (1.1). Thus, combining the ideas from [45] with Hardy-Rogers contractions (see [38]) emerged the notion of interpolative Hardy-Rogers contractions. The following result from [49] ensures the existence of a fixed point for these mappings.

Theorem 4.12 (see Theorem 4 from [49]). *Let (X, d) be a complete metric space and $T : X \to X$ an interpolative Hardy-Rogers type contraction, i.e. there exists $\lambda \in [0, 1)$ and $\alpha, \beta, \gamma \in (0, 1)$ with $\alpha + \beta + \gamma < 1$, such that*

$$d(Tx, Ty) \leq \lambda[d(x, y)]^{\beta} \cdot [d(x, Tx)]^{\alpha} \cdot [d(y, Ty)]^{\gamma} \cdot \left[\frac{1}{2}d(x, Ty) + d(y, Tx)\right]^{1-\alpha-\beta-\gamma} \tag{4.6}$$

for all $x, y \in X \setminus Fix\{T\}$. Then, T has a fixed point in X.

Furthermore, interpolative Hardy-Rogers type contractions were generalized by relaxing the topology of the space. In [49], a fixed point theorem for these mappings in partial metric spaces was proven:

Theorem 4.13 (see Theorem 5 from [49]). *Let (X, ρ) be a complete partial metric space and $T : X \to X$ an interpolative Hardy-Rogers type contraction. Then, T has a fixed point in X.*

The literature contains many more results related to interpolative Hardy-Rogers contractions, from which we mention the following, in chronological order:

- Interpolative Hardy-Rogers type $\mathcal{Z}$-contraction obtained via simulation function (see [9] and [68]), see [50],
- Common fixed point in quasi partial b-metric space, see [73],
- Interpolative Hardy-Rogers and Reich-Rus-Ćirić type contractions in rectangular b-metric space and b-metric spaces, see [19],
- $\omega - \psi$ interpolative contractive of Suzuki-type based on ω-orbital admissible mappings (see [93], [82]), cyclic mappings [23], see [106],
- -Interpolative Hardy–Rogers type contractions in b-metric spaces, see [26],
- Set-valued interpolative Hardy-Rogers in complete b-metric spaces, see [2],
- Results obtained via admissible mappings in quasi-partial b-metric space, see [33] ,
- (ϕ, ψ)-type $\mathcal{Z}$-contraction based on quasi triangular θ-orbital admissible mapping (see [82, 93]), see [66],
- Interpolative mappings of Suzuki-type combined with simulation functions, see [78],
- Multivalued interpolative Hardy-Rogers type $\mathcal{Z}$-contraction, see [59],
- Results in modular spaces, see [90],
- Results in quasi-partial b-metric spaces, see [108],
- Generalized results using F-contraction based on the generalization of Banach's fixed point introduced by Wardowski in [110], see [107],
- Enriched contraction, see [85],
- Fuzzy contractions, see [75],
- Common fixed points, see [22],
- Interpolative cyclic contractions, see [23].

5. Interpolative Reich-Rus-Ćirić Contractions

Theorem 5.14 (see Theorem 4 in [46]). *Let (X, ρ) be partial metric space and $T : X \to X$ an interpolative Reich–Rus–Ćirić type contraction, i.e. there exist the constants $\lambda \in [0, 1)$ and $\alpha, \beta \in (0, 1$*

such that

$$\rho(Tx,Ty) \le \lambda[\rho(x,y)]^{\beta} \cdot [\rho(x,Tx)]^{\alpha} \cdot [d(y,Ty)]^{1-\alpha-\beta} \tag{5.7}$$

for all $x, y \in X \setminus Fix\{X\}$.

The notion of interpolative Reich-Rus-Ćirić contractions sparked a great interest in the research community as many papers rely on this notions, such as the following:

- Extended interpolative Reich–Rus-Ćirić type F-contraction based on the generalization of Banach's fixed point introduced by Wardowski in [110], see [74],
- ω-interpolative weakly contractive mappings type in [11],
- ω-interpolative Reich-Rus-Ćirić contractions via Branciari distance [12],
- Interpolative Reich-Rus-Ćirić $\mathcal{Z}$-type contraction obtained via simulation functions [51]
- Interpolative Reich-Rus-Ćirić type contractions in rectangular b-metric space and b-metric spaces, see [19],
- Common fixed point in quasi partial b-metric space, see [73],
- g-interpolative Reich-Rus-Ćirić contractions in b-metric spaces, see [25], [26],
- Rus–Reich–Ciric contractions in rectangular quasi-partial b-metric spaces, see [32],
- Results in modular spaces, see [90],
- Weakly contractive mappings in modular spaces, see [70],
- Reich–Rus-Ćirić $(\alpha, \beta, \psi, \phi)$-interpolative contractions which unify Proinov-type contractions (see [84]), interpolative contractions and ample spectrum contractions (see [89]), see [55]
- Common fixed point based on Perov operator (see [80], [81]) which satisfy Suzuki type mappings (see [83], [98], [99]), see [57],
- Best proximity points results, see [92],
- Fuzzy contractions, see [75],
- Cyclic contractions, see [21],
- Results in controlled metric spaces, see [97],
- Results in hyperbolic complex valued metric spaces, see [109],
- Extensions to relational metric spaces, see [101].

6. Interpolative Jaggi Type Contractions

In [47], interpolative contractions were combined with Jaggi type contractions [41]:

Definition 6.6. *A self-mapping T on a complete metric space (M,d) is called a Jaggi type hybrid contraction if there exists a function $\psi \in \Psi$ such that*

$$d(Tx,Ty) \le \psi(J_s(T(x,y)))$$

for all distinct $x, y \in M$ where $s \ge 0$ and $\sigma_i \ge 0$, $i = 1,2$, with $\sigma_1 + \sigma_2 = 1$. Here,

$$J_s(T(x,y)) = \begin{cases} \left[\sigma_1 \frac{d(x,Tx)\cdot d(y,Ty)}{d(x,y)}^{s} + \sigma_2 (d(x,y))^s\right]^{1/s} & \text{if } s>0, x\neq y,\\ (d(x,Tx))^{\sigma_1}(d(y,Ty))^{\sigma_2} & \text{if } s=0, x,y\in M\setminus FT(M),\end{cases}$$

where $FT(M) = \{z \in M : Tz = z\}$.

Theorem 6.15. *A continuous self-mapping T on (M,d) possesses a fixed point x provided that T is a Jaggi type hybrid contraction. Moreover, for any $x_0 \in M$, the sequence $\{T^n x_0\}$ converges to x.*

- Jaggi hybrid type contractions and Suzuki type contractions with α-orbital admissible mappings, see [76],

- Hybrid Jaggi-Meir-Keeler type contraction, see [60],
- multivalued combining of Jaggi-type hybrid contraction and Suzuki-type hybrid contraction, see [104],
- Results in metric space equipped with a graph, see [42],
- Jaggi-type contractions combined with Pata-type inequality in metric spaces, see [105].

7. Interpolative Meir-Keeler Contractions

In [56], Karapınar introduced the notion of interpolative Kannan-Meir-Keeler as follows:

Definition 7.7. *Let (X, d) be a complete metric space. A mapping $T : X \to X$ is said to be an interpolative Kannan-Meir-Keeler type contraction on X if there exists $\gamma \in (0, 1)$ such that for every $x, y \in X \setminus Fix(T)$, the following conditions hold:*

(i) Given $\varepsilon > 0$, there exists $\delta > 0$ such that

$$\varepsilon < [d(x, Tx)]^{\gamma}[d(y, Ty)]^{1-\gamma} < \varepsilon + \delta \Rightarrow d(Tx, Ty) \leq \varepsilon,$$

(ii)

$$d(Tx, Ty) < [d(x, Tx)]^{\gamma}[d(y, Ty)]^{1-\gamma}.$$

Karapınar proved the following fixed point result for there mappings:

Theorem 7.16. *On a complete metric space (X, d), any interpolative Kannan-Meir-Keeler contraction $T : X \to X$ has a fixed point.*

The concept was further extended in several papers:

- Hybrid Jaggi type contractions, see [60],
- Results in modular spaces, see [58],
- Interpolative Meir-Keeler contraction of rational Das-Gupta form, see [91],
- Fixed-figure result, see [100],
- Cyclic interpolative Kannan-Meir-Keeler, see [24],
- Generalized Meir-Keeler contractive condition for a pair of self maps in a fuzzy metric space, see [40].

8. Interpolative Metric Spaces

Very recently, based on interpolative contractions, Karapınar introduced in [62], [63] a more general metric space called interpolative metric space defined as follows:

Definition 8.8. *Let X be a nonempty set. We say that $d : X \times X \to [0, +\infty)$ is (α, c)-interpolative metric if*

(m_1) *$d(x, y) = 0$ if and only if $x = y$ for all $x, y \in X$,*
(m_2) *$d(x, y) = d(y, x)$ for all $x, y \in X$,*
(m_3) *there exist an $\alpha \in (0, 1)$ and $c \geq 0$ such that*

$$d(x, y) \leq d(x, z) + d(z, y) + c\,(d(x, z))^{\alpha}\,(d(z, y))^{1-\alpha}$$

for all $(x, y, z) \in X \times X \times X$.

Then, we call (X, d) an (α, c)-interpolative metric space.

Let us note that every metric space can be regarded as an (α, c)-interpolative metric space with $c = 0$. However, the reverse of this statement does not hold (see Example 1.1 from [62]). These metric spaces were further studied in [64], where fixed point theorems related to (c)-comparison functions are provided and [14], where the are studied Ćirić type contractions.

9. More Results Obtained Modifying the Contractive Condition in Generalized Metric Spaces

In [52], there was introduced the concept of hybrid contractions, a notion which is based on interpolative contractions, as follows:

Definition 9.9. *Let (X, d) be a metric space. A self-mapping f is called an admissible hybrid contraction, if there exist $\psi \in \Psi$ and $\alpha : X \times X \to [0, \infty)$ such that*

$$\alpha(x, y)d(fx, fy) \leq \psi\left(R_f^q(x, y)\right),$$

where $q \geq 0$ and $\lambda_i \geq 0$, $i = 1, 2, 3, 4, 5$ such that $\sum_{i=1}^5 \lambda_i = 1$ and

$$R_f^q d(x,y) = \begin{cases} (\lambda_1 d^q(x,y) + \lambda_2 d^q(x,fx) + \lambda_3 d^q(y,fy) + \lambda_4 \left(\frac{d(y,fy)(1+d(x,fx))}{1+d(x,y)}\right)^q \\ +\lambda_5 \left(\frac{d(y,fx)(1+d(x,fy))}{1+d(x,y)}\right)^q)^{\frac{1}{q}} \text{ for } q > 0, x, y \in X, \\ \\ (d(x,y))^{\lambda_1} \cdot (d(x,fx))^{\lambda_2} \cdot (d(y,fy))^{\lambda_3} \cdot \left(\frac{d(y,fy)(1+d(x,fx))}{1+d(x,y)}\right)^{\lambda_4} \\ \cdot \left(\frac{d(x,fy)+d(y,fx)}{2}\right)^{\lambda_5} \text{ for } q = 0, x, y \in X \setminus Fixf(X), \end{cases}$$

where $Fixf(X) = \{x \in X : f(x) = x\}$.

For these mappings, a fixed point result was proved in [52]:

Theorem 9.17. *Let (X, d) be a complete metric space and let f be an admissible hybrid contraction. Suppose also that:*

- *(i) f is triangular α-orbital admissible,*
- *(ii) there exists $x_0 \in X$ such that $\alpha(x_0, f(x_0)) \geq 1$,*
- *(iii) either f is continuous or*
- *(iv) f^2 is continuous and $\alpha(fx, x) \geq 1$ for any $x \in Fixf^2(X)$.*

Then f has a fixed point.

These mappings were further studied using simulation functions in b-metric spaces in [48] and [17], extended b-metric spaces [65]. For more details on these mappings, see [54] and the references cited herein. Other generalized contractions were used to obtain new results for interpolative type mappings:

- Chatterjea contractions were studied in quasi-partial b-metric spaces, see [30] which were further extended via admissible mappings in [31] and using Suzuki type mappings in [34],
- Geraghty contractions were extended to hybrid contractions via admissible mappings in complete metric spaces in [53]. New results related to Geraghty mappings were also obtained combined with Wardowski and Hardy-Rogers contractions in [15], and also, results in b-metric spaces can be found in [4].

10. Applications

Among the many applications that arose from the concept of interpolative contractions, we list the following in order of publication:

- Solve Volterra fractional type integral equation using Kannan-interpolative contractions and Reich-Rus-Ciric interpolative contractions as particular cases of hybrid contractions, see [3],

- Solving non-linear matrix equations using interpolative Matkowski type contraction, see [35],
- Existence of solutions to fractional Navier–Stokes and fractional-functional differential equations using hybrid contractions, see [37],
- Solving nonlinear integral equations via enriched interpolative cyclic Kannan contractions, see [8],
- Existence of solutions to integral equation and fractional differential equation obtained via orthogonal interpolative versions of Kannan type, Chatterjea type, Ćirić-Reich-Rus type and Hardy-Rogers type (T, S)-contractions, see [77],
- Fredholm integral problems solved via dynamic interpolative contractions of various types and to establish several conclusions in the context of F-metric space, see [39],
- New solvability conditions of Fredholm-type integral inclusions via L-fuzzy contractions, see [96],
- Integral equations solved via interpolative Reich-Istrastescu type contractions in orthogonal b-metric spaces, see [20],
- Solving variational inequality problems via MR-Kannan interpolative type contractions (see [6]), see [7].

11. Conclusion

The main goal of this short survey is to collect several recent fixed-point results obtained by modifying the "Kannan-type interpolative contraction". Regarding the common overlapping problem in recent peer-reviewed publications, such a survey may help avoid overlapping the results.

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