Review of Literature

The fundamental research and the recent developments in literature in the field of topology have been lined up in this section.

Topology

Topology is a widely studied branch of mathematics which has its base in geometry and set theory. It was initiated by the great mathematician Henri Poincare in 19^{th} century. Topology plays an important role in pure and applied mathematics which are concerned with the spatial properties of objects which are preserved under bi-continuous deformations i.e., the homeomorphisms. Topological structures are suitable model for mathematicians for formulation of both qualitative and quantitative data. Moreover, topology is significant not only in mathematics but also in the diverse fields of science.

Various Closed Sets and Open Sets

Initially, the characterization of topology was given in terms of open sets. Taking up the study Stone [1937] introduced the regular open sets which was the stronger form of open sets. Levine [1963] introduced a weaker form of open sets called semi-open sets. α-open sets, a very new concept of topology was defined and studied by Njastad [1965], which lies between open sets and semi-open sets. Levine [1970] have generalized the closed set and named it as g-closed sets in topological spaces and framed the base for studying the properties of them. Veera Kumar [2000] defined g^*-closed sets in topological spaces and investigated its properties. By considering Levine's path several researchers studied various notion analogous to his generalized closed sets using the closure operators and the openness of the supersets.

Later Mashhour et al. [1983] introduced the notion of α-closed sets in topological spaces and derived its fundamental properties. A generalization to α-closed sets was given by Maki et al. [1993, 1994]. They have defined α-generalized closed sets and generalized α-closed sets in topological spaces and derived their properties which are much useful for the researchers to compare and analyze their sets.

Maki [1986] predominantly initiated to study the notion Λ-sets in topological spaces which is the intersection of all open supersets of the subsets of the topological spaces. Using the notion of closed sets and Λ-sets, Francisco G. Arenas et al. [1997] introduced λ-closed sets which is defined to be the intersection of Λ-sets and closed sets. Caldas and Dontchev [2000] introduced the concept of $G.\Lambda_s$-sets and $G.\vee_s$-sets in topological spaces and presented their properties and characterizations. Georgiou et al. [2004] presented the notions of Λ_δ-sets, (Λ, δ)-sets and they have analyzed their properties as well. Noiri and Hatir [2004] introduced Λ_{sp}-sets in topological spaces and analysed their properties and characterisation theorems. Caldas and Jafari [2005] introduced two new separation axioms in view of λ-closed sets and derived many characterizations. Caldas et al. [2006 b] defined and studied Λ_b-closed sets in topological spaces and characterized them. Caldas et al. [2007 b] studied λ-derived, λ-border, λ-frontier and λ-exterior of a set using the concept of λ-open sets. They have also defined Λ-g-closed sets and studied its properties. Caldas et al. [2007 a] have provided definitions for Λ_α-sets and (Λ, α)-sets which induced many researchers to work on similar concepts. Caldas et al. [2008 a] investigated two more classes of sets namely Λ_g-closed sets, $g\Lambda$-closed sets and investigated their properties. They also studied the relationship between Λ_g-closed sets and Λ-g-closed sets. Further, $\tilde{g}_\alpha$-closed sets was studied by Saeid Jafari et al. [2010] and studied many basic properties and theorems.

Jeyanthi et al. [2011] introduced Λ_r-sets and studied some weak separation axioms using Λ_r-open sets and Λ_r-closure operators. Gilbert Rani et al. [2011] introduced the definition of Λ^λ-closed sets and analyzed many of its properties. Pious Missier and Vijilius Helena Raj [2012 a] introduced and studied the properties of $gs\Lambda$-closed sets. In the same way, $g^*\Lambda$-closed set was introduced by Pious Missier and Vijilius Helena Raj [2012 b] and have given its associations and characterizations. Khalaf and Namiq [2013] studied the properties of λ_c-open sets and defined many separation axioms regarding the defined open set. Punitha Tharani and Delcia [2017] introduced the definition of $g^*\alpha$-closed sets using α-closure and g^*-open sets. Generalized (Λ, b)-closed sets was introduced and studied by Chawalit Boonpok [2017] and he also studied the characterizations of Λ_b-regular spaces and Λ_b-normal spaces. Sarhad F. Namiq [2017 b] defined the new classes of sets called λ_c-closed sets and studied many of its properties. He also introduced the definitions of λ_c-limit point, λ_c-derived set, λ_c-closure operator and λ_c-interior operator in topological spaces. Sayamapada modak and Takashi Noiri [2019] introduced the notions λ-locally closed sets, Λ_λ-closed sets and λg-closed sets and obtained some decompositions of closed sets and continuity in topological spaces.

Recently, Matheswaran and Rajakumar [2019] have proposed and examined the topological characters of $g^*s\Lambda$-closed and $g^*s\Lambda$-open sets and their rapport with many other generalized closed sets were also examined. Parveen Banu and Mohamed Sheriff [2019] introduced new classes of sets called C_δ-set, BC_δ-sets and η_δ-sets in topological spaces also they have studied many decompositions of closed sets related to δ-sets. Chawalit Boonpok [2020] presented the new concept by defining Λ_{sp}-sets and (Λ, sp)-open sets with the assistance of β-open sets. He has also characterized the defined sets with respect to some predefined spaces.

Meenakshi and Sivakamasundari [2019, 2020] introduced the study of J-closed sets and J^{**}-closed sets using η^*-closure operator. Later, Balamani [2020 b] introduced the new form of closed sets called $g^{**}\Lambda$-closed sets in topological spaces and studied its properties. Azzam and Nasef [2020] introduced two new notions via Maki's Λ-set namely β-Λ-set and Λ-β-sets in topological spaces. They have discussed the properties and characterizations of the defined family of sets. The applications of $g^{**}\Lambda$-closed sets was investigated by Balamani [2020 a] and many of its interesting results were obtained.

Amutha and Dhana Balan [2021] have obtained a new class of sets called Λ_{rs}-set, Λ_{rs}-open sets and Λ_{rs}-closed sets in topological spaces using regular semi open sets and regular semi closed sets and studied their properties and connections between various sets. Shyamapada Modak and Jiarul Hoque [2022] defined and studied the properties of $gb\Lambda$-closed sets in view of kernel, s-kernal and b-kernal in topological spaces. Subsequent definitions like $s(\Lambda, sp)$-open sets, $p(\Lambda, sp)$-open sets, $\alpha(\Lambda, sp)$-open sets, $\beta(\Lambda, sp)$-open sets and $b(\Lambda, sp)$-open sets were defined and analysed by Chawalit Boonpok and Jeeranunt Khampakdee [2022].

Continuity concepts

Mappings from one topology to the other is a vital area of study in topological spaces. One such area is continuity; continuous mappings are the study of preimages of the respective closed (open) sets. Levine [1960] established the idea of decompositions of continuous maps and strongly continuous mappings. Special forms such as strongly and completely continuous maps, totally continuous maps, super continuous maps and perfectly continuous maps were introduced respectively by Arya and Gupta [1974], Jain [1980], Munshi and Bassan [1982] and Noiri [1984]. Mashhour et al. [1983] studied α-continuity in topological spaces.

Later, Balachandran et al. [1991] came up and studied the generalizations of continuity, named g-continuous maps. Devi et al. [1997] portrayed the concepts of αg-continuous maps and $g\alpha$-continuous maps and characterized them. Francisco G. Arenas et al. [1997] studied the weaker form of continuous maps called λ-continuous maps. After the initiation of λ-continuity many researchers studied the properties and characterizations related to λ-continuity with respect to their respective closed sets utilizing λ-closed sets.

Crossley and Hildebrand [1972] initiated the study of irresolute maps and proved that these are stronger than semi continuous maps and independent with continuous maps. Weak and strong forms of irresolute maps were studied by Caldas [2000] in which the definition of contra irresolute map was presented. Using the definition of β-open sets, strongly β-irresolute maps and weakly β-irresolute maps were formulated and studied by Noiri [2003]. Caldas et al. [2003] defined and studied Λ_p-continuous maps, Λ_p-irresolute maps and $\vee_p$-closed maps using Λ_p-sets and $\vee_p$-sets in topological spaces. They have also examined all the fundamental properties and theorems.

Bai and Zuo [2011] introduced the definition of g-α-irresolute maps and characterized it. Pious Missier and Vijilius Helena Raj [2013] introduced the concept of $gs\Lambda$-continuous maps and investigated many of its theorems and interrelations. Alias B. Khalaf and Sarhad F. Namiq [2012] investigated the concept of $(\lambda,\gamma)^*$-continuous maps using the definition of generalized λ-closed sets via s-operation and constructed many productive theorems and characterizations. Pious Missier and Anto [2015] studied the properties of $\hat{g}^*s$-continuous maps and $\hat{g}^*s$-irresolute maps using $\hat{g}^*s$-closed sets in topological spaces and derived many of their characterizations.

Vijilius Helena Raj [2017] studied a new class of function called $gs\Lambda$-irresolute maps in topological spaces and studied its characterizations. Vijilius Helena Raj and Srinivasa [2017] analysed a new class of maps called $g^*\Lambda$-irresolute map and contra $g^*\Lambda$-irresolute map and found that $g^*\Lambda$-irresolute maps is a stronger form of $g^*\Lambda$-continuous map. Chawalit Boonpok and Chokchai Viriyapong [2022] have studied several characterizations of weakly (Λ,p)-continuous maps using the concepts of Λ_p-sets and (Λ,p)-closed sets in view of preopen sets and pre-closed sets. With the notion of continuity which is the core concept of topology many authors have introduced and studied the nature of their respective closed sets and characterized them.

Closed Maps and Open Maps

After the study of pre images of mappings the next view is on the images of mappings. The concept of closed maps and open maps came into existence in topological spaces. Several authors introduced the weaker form of closed and open maps and promoted their characterizations. Likewise, Malghan [1982] introduced and investigated the generalized closed maps denoted by g-closed maps. Mashhour et al. [1983] studied the properties of α-closed maps in topological spaces. Semi-generalized closed maps and generalized semi closed maps were defined and studied by Devi et al. [1993]. Contra conditions to open and closed maps were studied by Baker [1997] namely contra open sets and contra closed sets. Also, Devi et al. [1998] introduced and analyzed αg-closed maps and $g\alpha$-closed maps.

Special forms of closed and open maps were also studied by many researchers. Thivagar [1991] introduced and studied the weak and strong forms of open maps called quasi α-open maps and strongly α-open maps. Govindappa Navalagi [2011] presented the concepts of quasi α-closed maps and strongly α-closed maps in topological spaces. Later, Devi and Parimala [2009] studied the quasi $\alpha\psi$-open mappings. Vijilius Helena Raj and Pious Missier [2012] studied the class of maps named $gs\Lambda$-closed and $gs\Lambda$-open maps in topological spaces and investigated their properties. Devamanoharan et al. [2013] introduced the ρ-closed maps and analysed their important properties and characterizations.

Homeomorphisms

Homeomorphisms play the same role in topology as that of linear isomorphisms play in linear algebra. In view of identifying such maps, Maki et al. [1991] introduced and examined g-homeomorphisms and gc-homeomorphisms in topological spaces. Various other authors like Caldas et al. [2009], Vadivel and Vairamanickam [2010], Gilbert Rani and Pious Missier [2011], Devamanoharan et al. [2013], Padma et al. [2015], introduced $\tilde{g}$-homeomorphisms, $rg\alpha$-homeomorphims, Λ^{λ}-homeomorphisms, ρ and ρ^*-homeomorphisms, Q^*-homeomorphisms respectively.

Murugavalli and Pushpalatha [2016] introduced the concept of $g\lambda$-homeomorphisms in topological spaces using $g\lambda$-closed sets. They all have also characterized their fundamental properties. Quite recently, Meenakshi [2020] defined J-homeomorphisms using J-closed sets in topological spaces. Further, Delcia and Punitha Tharani [2021] studied the properties of $g^*\alpha$-homeomorphisms in topological spaces.

Quotient Maps

Lellis Thivagar [1991] introduced the notion of quotient maps, α-quotient maps, semi-quotient maps and pre-quotient maps in topological spaces which were very new in the field of general topology and paved the way for many researchers on general topology to work on quotient maps. Again, $\tilde{g}_{\alpha}$-quotient mappings were defined and studied by Lellis Thivagar and Nirmala Rebecca Paul [2010].

Later, various researchers like Ravi et al. [2011], Umadevi I. Neeli [2012], Balamani and Parvathi [2017], Chidanand Badiger et al. [2020], Meenakshi [2020] developed their concept of closed sets to αgs-quotient maps, $g\delta s$-quotient maps, $\psi^{*}\alpha$-quotient maps, rw-quotient maps, J-quotient maps respectively.

Contra Continuity Concepts

Continuous maps are associated with yet another case of study called contra cases in which the negative side of the mappings are taken into account. Gangster and Reilly [1989] introduced the notion of LC-continuity using the concept of locally closed sets. Following this, Dontchev [1996] introduced the stronger form of LC-continuity called contra continuous maps. This initiation was put forward by Dontchev and Noiri [1999] to study contra semi continuous mappings. Saeid Jafari and Takashi Noiri [2001] introduced contra α-continuous maps. Saeid Jafari and Takashi Noiri [2002] gave interesting results regarding contra pre continuous mappings. Contra λ-continuous maps were studied by Caldas et al. [2006 a] and initiated the study related to λ-continuous maps.

Like generalizations to continuity, contra continuous maps were also generalized under the name contra g-continuous maps which was defined by Caldas et al. [2007 c]. Further, Caldas [2000] proposed the concept of contra irresolute maps which was found to be the stronger form of ap-irresoluteness. Vijilius Helena Raj and Pious Missier [2016] defined contra $gs\Lambda$-irresolute maps via $gs\Lambda$-closed sets in topological spaces.

Contra $(\lambda, \gamma)^*$-continuous maps was defined and studied via s-operations by Sarhad F. Namiq [2017 a] and they have also established several properties and interrelations of their respective maps. Later on, many researchers gave many similar definitions of contra irresoluteness with their respective closed sets and open sets.

Bi-Contra Continuity Concepts

The particular idea of contra continuity with two-way negative effects were initiated by Caldas et al. [2008 b], wherein they have used the contra continuities to achieve the definition of bi-contra continuous maps. They also have defined bi-contra α-continuous maps using α-continuity. The properties, characterizations and implications of the defined bi-contra continuities were analyzed. Later Lellis Thivagar et al. [2017] has extended this bi-contra continuity in topological spaces to nano topological spaces and gave an interesting application in the field of biotechnology. This has become a reputed article among the researchers.