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OPERATIONS ON TOPOLOGICAL SPACES

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Abstract: *one of the most important sections of modern general topology is the theory of cardinal-valued invariants of topological spaces. Among these invariants, the second most important is density. In the hierarchy of spaces determined by the density, the spaces of the least infinite density occupy the central place, i.e. spaces that contain countable everywhere dense subspaces. Historically, these spaces are called separable. In this paper T zero topological space, T one topological space, Hausdorff space, regular spaces, full regular space, normal spaces are studied.*
Keywords: *topological space, Hausdorff space, regular space.*

ОПЕРАЦИИ НА ТОПОЛОГИЧЕСКИХ ПРОСТРАНСТВАХ

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Аннотация: *одним из важнейших разделов современной общей топологии является теория кардинальнозначных инвариантов топологических пространств. Среди этих инвариантов вторым по значимости является плотность. В определяемой плотностью иерархии пространств центральное место занимают пространства наименьшей бесконечной плотности, т.е. пространства, которые содержат счетные всюду плотные подпространства. Исторически сложилось так, что эти пространства называются сепарабельными. В этой статье изучаются T ноль топологическое пространство, T один топологическое пространство, пространство Хаусдорфа, регулярные пространства, полное регулярное пространство, нормальные пространства.*
Ключевые слова: *топологическое пространство, Хаусдорфово пространство, регулярное пространство.*

Definition 1. For any two different points x and y, at least one point had a neighborhood that did not contain another point.

Topological spaces satisfying the zero separability axiom are called T_0 *–spaces* [1-9].

Proposition 1. A topological space X satisfies the first separability axiom T_1 if and only if every one-point subset of it is closed.

Remark 1. There is a space that is an T_0 -space, but is not a T_1 -space.

Example 1. Let $X = \{a, b\}$ be a set consisting of two elements a and b. In the set X, we define the topology as follows: $\tau = \{\ emptyset, \{a\}, X\ \}$ One can easily check that (X, τ) is a topological space. The topological space (X, τ) is a T_0 -space, but not a T_1 –space [6-7].

Definition 2. It is said that the topological space (X, τ) satisfies the second separability axiom if, for each pair of distinct points $x_1\ \neq\ x_2 \in X$ there are neighborhoods of Ox_1 and Ox_2 such that $Ox_1\ \cap\quad Ox_2 = \emptyset$.

Topological spaces that satisfy this condition are called T_2 -spaces or Hausdorff spaces.

Obviously, every T_2 -space is a T_1 -space.

Remark 2. There is a space that is an T_1 -space, but is not a T_2 -space.

Example 2. Let $N = \{\ 1, 2, \dots, n, \dots\ \}$ be the set of all natural numbers . The set of all natural numbers is introduced by the topology as follows: $\tau = \{\ A \subset N: N\backslash A\ \ finite\ \ or\ \ A = \emptyset\ \}$. One can easily see that $(\ N, \tau\ )$ is a topological space on N. We claim that $(\ N, \tau\ )$ is a T_1 -space. Let $x_1\ \neq\ x_2 \in N$ be two different points in the space N. The sets $A_1 = N\backslash x_2$ and $A_2 = N\backslash x_1$ are the neighborhoods of the points x_1 and x_2 respectively. It is clear that $x_2 \notin A_1$ and $x_1 \notin A_2$, $(\ N, \tau\ )$ is a T_1 -space.

Now we show that $(\ N, \tau\ )$ is not a T_2 -space. Assume the contrary that there are such different points, $x_1\ \neq\ x_2 \in N$ have disjoint neighborhoods Ax_1 and Ax_2, that is, $Ax_1\ \cap\ Ax_2\ = \emptyset$. Consider the additions

$N\backslash(\ Ax_1\ \cap\quad Ax_2\ )\ =\ (\ N\backslash Ax_1)\ \cup\quad(\ N\backslash Ax_1) = N.$

By hypothesis, $N\backslash Ax_1$ and $N\backslash Ax_2$ are finite sets, and the union of finite sets is finite. We have obtained a contradiction that the set of all natural numbers is infinite.

Definition 3. It is said that a topological space satisfies the T_3 axiom of separability if for any point $x \in X$ and any closed set not containing this point $F \subset X$ there are neighborhoods Ox and OF such that $Ox \cap\ OF\ =\ \emptyset$.

If a space satisfies both the T_1 and T_3 -separation axioms, then we call such spaces regular.

It is clear that every regular space is Hausdorff.

Remark 3. There is a Hausdorff space that is not regular.

Consider the set R of all real numbers and define the topology in R using the system of neighborhoods of all points $x \neq 0$ the same as on the number line; neighborhoods of the point $x = 0$ are obtained by subtracting from any interval containing this point all points of the form $\frac{1}{n}$ that fall into this interval, where n is a positive integer. The space R is Hausdorff; the set of all points of the form $\frac{1}{n}$ is closed in R; every neighborhood of this closed set intersects every neighborhood of the point 0.

Theorem 1. A topological space (X, τ) is regular if and only if for every point $x \in X$ and any neighborhood Ox such a neighborhood O_1x of this point that $[\ O_1x\ ]\ \ subset\ Ox$.

Definition 4. It is said that the topological space (X, τ) satisfies the $T_{3\frac{1}{2}}$ -separability axiom if for any point $x \in X$ and any closed set not containing this point $F\ \ subsetX$ there is a continuous function $f: X\ \ \rightarrow [0, 1]$, such that

$f(x) = 0$ and $f(x) = 1$ for $x \in F$.

If a space satisfies both T_1 and $T_{3\frac{1}{2}}$ -separable axioms, then such spaces are called Tikhonov, or completely regular, or $T_{3\frac{1}{2}}$ -spaces.

It is clear that any regular space is completely regular. Indeed, let $x \in X$ and $x\ notinF$ be an arbitrary nonempty closed subset of X. Since X is a completely regular space, there exists a continuous function $f\ :\ X\ \ to\ [\ 0,1\ ]$, such that $f(x) = 0$ and $f(x) = 1$ for the set $x \in F$. Then the neighborhoods $Ox = f^{-1}\left(\left[\ 0,\frac{1}{2}\right)\right)$ and $OF = f^{-1}\left(\left(\frac{1}{2},1\right]\right)$ have an empty intersection, which means that any regular space is completely regular.

Theorem 2. The T_1 -space X is a completely regular space if and only if for every point $x \in X$ and any neighborhood U from a fixed prebase P there is a continuous function $f\ :\ X\ \ to\ [\ 0,1\ ]$, such that $f(x) = 0$ and $f(y) = 1$ for $y \in X \backslash U$.

Definition 5. It is said that a topological space (X, τ) satisfies the T_4-axiom of separability if, for each pair of disjoint closed sets $A, B \subset X$, there are open sets U, V such that

$$A \subset U, B \subset V\ and\ U \cap V \neq \emptyset$$

If a space also satisfies the -axiom of separability, then we call such spaces normal or -space. It is clear that every normal space is a regular space.

Proposition 1. For any two disjoint open sets, the closure of either of them does not intersect with the other.

The study of spaces helps the tasks set in them [10-15].

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