

**TOPOLOGICALLY TRANSITIVE, MIXING
AND SENSITIVE PROPERTIES OF SET-
VALUED DYNAMICAL SYSTEMS**

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**MASTER OF SCIENCE
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**TOPOLOGICALLY TRANSITIVE, MIXING AND SENSITIVE
PROPERTIES OF SET-VALUED DYNAMICAL SYSTEMS**

WONG KOON SANG

April 2020

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Topological dynamics is a one of the branches in the field of dynamical systems where the properties and behaviour of the system is studied from the perspective of geometric and topology. Various topological notions have been introduced by mathematicians and many results on their properties for single-valued dynamical systems can be found. This thesis focuses on three topological notions and their properties for dynamical systems under set-valued setting. The first two notions are topological transitivity and mixing for set-valued functions. An equivalent condition to express these notions is obtained and some special cases of topological transitivity are defined. Then, the relations between the notions and their special cases are investigated. The results are summarized into an implication diagram. In general, mixing will implies topological transitivity and the converse is not true. However, both notions for set-valued functions are equivalent when the space is restricted to compact interval. Besides that, the invariant properties of topological transitivity and mixing for set-valued dynamical system are shown. Some implications on the product set-valued dynamical systems constructed from two set-valued dynamical systems with different topological transitivity and mixing conditions are also obtained. The third topological notion is sensitivity. It is well known that sensitivity and topological transitivity are closely related with each other in single-valued dynamical systems and both are common ingredients in definitions of chaos. In set-valued case, similar results are obtained. Finally, a stronger form of sensitivity is introduced and its relation with mixing is obtained.

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**SIFAT TRANSITIF, PERCAMPURAN DAN KEPEKAAN
TOPOLOGI BAGI SISTEM DINAMIK BERNILAI SET**

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Dinamik topologi merupakan salah satu cabang dalam bidang sistem dinamik di mana sifat dan tingkah laku sistem dikaji dari sudut geometri dan topologi. Pelbagai tanggapan topologi telah diperkenalkan oleh ahli matematik dan banyak hasil pada sifat-sifatnya untuk sistem dinamik bernilai tunggal telah ditemui. Tesis ini fokus kepada tiga tanggapan topologi dan sifat-sifatnya untuk sistem dinamik bawah persekitaran bernilai set. Dua tanggapan pertama adalah transitif dan percampuran topologi untuk fungsi bernilai set. Satu keadaan setara untuk menyatakan sifat diperolehi dan beberapa kes khas bagi transitif topologi ditakrifkan. Kemudian, hubungan antara tanggapan dan kes khasnya dikaji. Hasil-hasil diringkaskan dalam gambar rajah implikasi. Secara umum, percampuran mengimplikasikan transitif topologi dan akasnya adalah tidak benar. Walau bagaimanapun, kedua-dua tanggapan bagi fungsi bernilai set adalah setara apabila ruang disekatkan kepada selang padat. Selain itu, sifat tak berubah transitif dan percampuran topologi untuk sistem dinamik bernilai set ditunjukkan. Beberapa implikasi pada sistem dinamik hasil darab bernilai set dibina daripada dua sistem dinamik dengan syarat transitif dan percampuran topologi yang berbeza juga diperolehi. Tanggapan topologi ketiga adalah kepekaan. Kepekaan dan transitif topologi dikenali ramai berkait rapat antara satu sama lain dalam sistem dinamik bernilai tunggal dan kedua-duanya merupakan ranuan biasa dalam takrifan kekalutan. Dalam kes bernilai set, hasil serupa diperolehi. Akhirnya, satu bentuk kepekaan yang lagi kukuh diperkenalkan dan hubungannya dengan percampuran diperolehi.