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On the bifurcation of Marotto's map and its application in image encryption

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Abstract

The aim of this paper is to address the codimension-one bifurcation of Marotto's map and its utility in image encryption. First of all, local stability analysis and local bifurcation analysis of fixed points of the considered map are investigated in details. According to the classical bifurcation theory and the center manifold theorem, the map exhibits various bifurcation types such as transcritical, flip and Neimark-sacker bifurcations. Second of all, the map is proven to be chaotic in the sense of Marotto. Since image encryption based on chaotic maps is very promising for cryptography, Marotto's map, compound chaos, and spatiotemporal chaos are combined to encrypt and decrypt images. Numerical simulations agree with the analytical framework for the complex dynamics of the map. Furthermore, different test images are used to demonstrate the effectiveness of the method implemented for encryption.

MSC (2010): 37E10, 37C75, 34C28.
keywords: Marotto's map; fixed points; stability; bifurcation; compound chaos; spatiotemporal chaos; image encryption.

1 Introduction

The study of nonlinear difference equations has gained a great interest in the past decades because they can display variety of complex dynamic behavior such as different types of bifurcations, periodic orbits and chaotic attractors [13,26,29,36–39, 49,60]. Indeed, the defining equations of many nonlinear systems have parameters and the question is how the dynamic behavior is changed when changing these parameters [15]. Two-dimensional maps have been used for modeling mathematical equations which describe certain dynamical process [5]. In many fields like