Reversible codes and applications to DNA

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Abstract

The importance of DNA for living creatures is a very well known fact. Furthermore, the rich structure and knowing the role of the structure of DNA has led the researchers to the direction where the structure of DNA can be realized in computing processes and computer related technologies. Recent studies show that DNA can storage data as a big digital memory and can be a good tool for error correction besides other applications. Both the form reverse and reversible-complement are well known properties of DNA. These two important properties that DNA enjoys are considered in the sets or in more narrow but practical sense in linear spaces. The algebraic structures of such spaces are then studied. The algebraic structures (linear subspaces, submodules) that enjoy these properties are called DNA codes. There have been studies on DNA codes that correspond to singleton or double DNA letter representations. The main goal in each study was to construct a linear code (or cyclic code) that enjoy the DNA properties. In this work, we define a new family of polynomials called coterm polynomials. By taking advantage of this family, we are able to find reversible and reversible-complement codes by using coterm polynomials that are not necessarily linear cyclic codes over commutative rings. Furthermore, optimal codes over some finite fields obtained by the coterm polynomials are constructed. Moreover, we identify k-bases of DNA with elements in the ring $\mathcal{R}_{2k} = \mathbb{F}_2[u]/(u^{2k} - 1)$. We are able to address the reversibility and complement problems in DNA codes over this ring. We define new rules that matches DNA bases and elements of the ring. Accordingly, we introduce a generating method suitable for obtaining DNA codes. With a freedom on the choice of k we are able to embed any DNA code in a suitable ring, giving an algebraic structure to the DNA codes. In order to illustrate the theoretical findings we have written some algorithms and programs in MAGMA and Mathematica softwares. The programs generate and control this DNA codes.

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