Portable and Random-Access DNA-Based Storage Systems

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Abstract

Despite the many advances in traditional data recording techniques, the surge of Big Data platforms and energy conservation issues have imposed new challenges to the storage community in terms of identifying extremely high volume, non-volatile and durable recording media. To address these challenges, the new paradigm of macromolecular storage was put forward by a number of researchers. Among all macromolecules used, DNA stands out in so far that it lends itself to implementations of recoding media of outstanding integrity and extremely high storage capacity.

Building upon the rapid growth of biotechnology systems for DNA synthesis and sequencing, we developed and implemented the first portable DNA-based rewritable and random access device. Our system is based on DNA editing, new alignment algorithms and constrained and error-control coding techniques that ensure data reliability, specificity and sensitivity of access, and at the same time, provide exceptionally high data storage capacity. The coding methods used include prefix-synchronized codes, and newly introduced profile codes and codes in the Damerau distance. As a proof of concept, we encoded in DNA parts of the Wikipedia pages of six universities in the USA and Citizen Kane images, selected specific content blocks and edited portions of the text within various positions in the blocks. We showed that error-free readouts may be achieved even with noisy nanopore MinION readout platforms.

Joint Work with: Ryan Gabrys, Han Mao Kia, Jian Ma, Hussein Tabatabaei Yazdi, Yongbo Yuan, and Huimin Zhao

Bio

Olgica Milenkovic is a professor of Electrical and Computer Engineering at the University of Illinois, Urbana-Champaign (UIUC), and Research Professor at the Coordinated Science Laboratory. She obtained her Masters Degree in Mathematics in 2001 and PhD in Electrical Engineering in 2002,
both from the University of Michigan, Ann Arbor. Prof. Milenkovic heads
a group focused on addressing unique interdisciplinary research challenges
spanning the areas of algorithm design and computing, bioinformatics, coding
theory, machine learning and signal processing. Her scholarly contributions
have been recognized by multiple awards, including the NSF Faculty Early
Career Development (CAREER) Award, the DARPA Young Faculty Award,
the Deans Excellence in Research Award, and several best paper awards. In
2013, she was elected a UIUC Center for Advanced Study Associate and Wil-
lett Scholar. In 2015, she became Distinguished Lecturer of the Information
Theory Society. From 2007 until now, she has served as Associate Editor of
the IEEE Transactions of Communications, the IEEE Transactions on Sig-
nal Processing, the IEEE Transactions on Information Theory and the IEEE
Transactions on Molecular, Biological and Multi-Scale Communications. In
2009, she was the Guest Editor in Chief of a special issue of the IEEE Trans-
actions on Information Theory on Molecular Biology and Neuroscience.

Faculty Host: Dimitris Metaxas