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Abstracts of Dr. Theses

Title: About formal models of computers and computations (dr. hab. theses)

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Abstract

The classical Turing model and modern biomolecular models of computer and computations, based on splicing are discussed.

The well known Shannon's problem to find the minimal universal Turing machines has been considered in chapter 1. Let be $UTM(m,n)$ denotes the class of universal Turing machines (TMs) with m states and n symbols. It is proved, that there are universal TMs in the following seven classes: $UTM(24,2)$, $UTM(10,3)$, $UTM(7,4)$, $UTM(5,5)$, $UTM(4,6)$, $UTM(3,10)$ and $UTM(2,18)$. These universal TMs are the smallest of known ones.

The P. Fischer's hierarchy $\mathcal{FTM}$ of subsets of TMs is completed. In particular, it is proved that there are universal U-machines (U-machine can execute only one of three microoperations of TM for one step) with 3 states and n symbols and 3 symbols and m states.

The immortality problem and uniform halting problem are considered for $\mathcal{FTM}$ in chapter 2. A tape of TM with designated scanned symbol and an internal state of the TM constitute an instantaneous description (ID) of the TM. The immortality problem is the problem of deciding, for a given TM, whether or not there exists an immortal ID (i. e. ID, which does not lead to terminal ID). If we consider only finite ID's, this problem is called uniform halting problem. In particular, it is proved that immortality problem is decidable for Post machines with 3 states and undecidable for Post machines with 4 states.

The mathematical models of biomolecular computer (DNA-computer), based on splicing rules, are considered in chapter 3.

Tomas Head drew the connections between molecular computers and formal language theory. He presented molecules as words over some alphabet and enzymes as so-called splicing rules. A splicing rule may be applicable to two molecules. It breaks both molecules at fixed locations, defined by the splicing rule, and recombines the initial string of one broken molecule with the final string of the second. Finite H systems with n test tubes are splicing systems of n test tubes over a common molecular alphabet, Σ, with a filter $F_i \subseteq \Sigma$ for each test tube. Initially, arbitrary many copies of molecules and enzymes (splicing rules) from a finite set of molecules and enzymes are given to the test tubes that produce new molecules by splicing and filtering. It is proved that there is an universal extended finite H systems with only 3 test tubes and that 4 test tubes suffices to generate any formal language.

A time-varying distributed H system (degree $n,\ n \geq 1$) is a splicing system which has the special features: at different moments one use different sets of splicing rules (these sets splicing rules are called degrees of this system). The passing from a set of rules to another one is specified in a cycle. It is proved that there is an universal time-varying distributed H system of degree 2. Both above results on molecular computer are the best of known ones.