Randomness as a Source of Efficiency

(extended abstract)

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The notion of **randomness** is one of the most fundamental and most discussed terms in science. Following the definition of dictionaries, an event is considered to be **random**, if it happens unpredictably and this unpredictability is not related to the incompleteness of our knowledge. An object is called **random**, if it is created without any plan and so it cannot be described in any shorter way than taking the object itself (i.e., by giving the full description of the object in detail). The question

"Does there exist true randomness?"

have been discussed since ancient times. This is a principal question of science because it asks whether everything is deterministic (i.e., whether the development is unambiguously determined) or nondeterministic (i.e., whether the deveopment is ambiguous). The fundamentals of current physical theories are based on quantum mechanics that assumes that the behavior of particles can be ambiguous and can be described in terms of random events. Similarly, biology uses randomness in order to explain the evolution. Mathematics developed the probability theory as a powerful instrument for investigating random events and for discovering properties of complex systems.

One of the main contributions of informatics to understanding the functioning of the world is related ti its research on the computational power of randomness. Computer scientists discovered that randomness can be applied to control systems and algorithms and that the efficiency and simplicity are the main features of such **randomized** systems designed. These features of randomized algorithms often made randomization a miraculous springboard for solving complex problems in various applications. Especially in the areas of communication, cryptography, data management, logistic and discrete optimization, randomization tends to be an indispensable part of the development of software systems. We know several situations and algorithmic tasks for which any deterministic approach leads to so much computer work that it is impossible to perform it in practice, but for which randomized methods can be successfully applied. This huge gain of going from an intractable amount of computer work (computational complexity) to short computations of randomized algorithms are paid for by the risk of computing a wrong output. But the probability of executing an erroneous computation of a randomized algorithm can often be reduced to below 1 over the age of the universe in seconds. This means that one pays for saving a huge amount of computing time with a very small loss in the degree of reliability. How to orchestrate such huge quantitative jumps in computational complexity by small relaxation of reliability (correctness) constraints and why such big gains for small prices are at all possible is the art of the algorithms design.

The main subject of our tutorial is to deal with the following questions.

Can this paradigmatic contribution of computer science be made available for pupils in secondary schools? Is this topic not too hard for teaching like quantum mechanics? Are there enough simple exercises enabling to train design and analysis of randomized algorithms in high schools?

Our aim is to show the way, in which this topic can be made available for pupils without presenting too many technicalities and without requiring the mastery of deep mathematical concepts. The gain is not only training some specific skills of an algorithm designer. Already a partial understanding of reasons, why applying randomization one can reach aims, that are unreachable in any deterministic way, has a philosophical depth and contributes to building of a new view on the development of the word. This computer science topic belongs among those subjects that enable to see computer science in the context of other scientific disciplines and to follow the dynamic and sometimes even dramatic development of scientific viewpoints. This is exactly that what one needs to fascinate the pupils and to win them for studying exactly our or close scientific disciplines.