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EVALUATION OF THE ADVANTAGES OF CALCULATING MATHEMATICAL EQUATIONS USING A HASH-BASED STRUCTURES MAPPING KEY TO VALUE

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Abstract

In the software world, many applications use the same equation. This requires their constant recalculation, leading to loss of time and resources. The article presents the data from a study comparing the time needed to calculate mathematical equations with the time needed to find the results in array of pre-calculated values.

Многие программные приложения используют одни и те же уравнения. Это требует их постоянного пересчета, что приводит к потере времени и ресурсов. В статье представлены исследования для сравнения времени вычисления математических уравнений с временем, необходимым для поиска результатов в массиве предварительно рассчитанных значений.

Introduction

Each computer program uses equation and performs calculations. As applications somewhat recreate the real world it sooner or later, the equations used to calculate various things will be repeated. The longer the humanity uses the computers, the more likely the same equations to be reused in different applications.

Such reuse and recalculation of the same equation leads to performing the same work on computers all over again. On the other hand, the complexity of the equations and the time to calculate them are related. That means the time of calculation increases with complexity. This would lead to irrational use of resources, computing power and inefficient work of computers.

Current paper presents a study that helps to determine is it faster an equation to be calculated or estimated result to be found among a group of pre-calculated values of the equation.

Storing pre-calculated results

Each equation is estimated in advance. That way during the execution the program doesn't waste time for calculation.

If the equation to be calculated is:

$$y = 1 - x^2 \tag{1}$$

the value of y is pre- calculated for various values of x. The calculated results are stored in hash-based structure mapping key to value. The key structure is the equation and the value - the result of calculation. For example, if x equals 1, according to (1) the key is "1*1+4"and the value is the results of the calculation - "5".

That way the equation is calculated in advance with thousands or millions of values of x and then the results are stored in the above-mentioned structure. Subsequently, if necessary the equation to be estimated (solved) with specific values instead of wasting time for calculation the ready response can be found among the many pre-calculated ones.

For purposes of the particular study each equation is estimated one million times with different random input parameters. The obtained data are stored in structures (described below) mapping key to a value. That way each structure contains one million pre-calculated equations with different input parameters.

Studied equations

The study covers two standard equations of physics:

1. Equation to calculate the time required for a body to fall freely from a height h1 to a height h2 - equation (2). Graphical visualization is shown in Fig. 1.

$$t = \frac{\arccos\sqrt{\frac{h_2}{h_1}} + \sqrt{\frac{h_2}{h_1}\left(1 - \frac{h_2}{h_1}\right)}}{\sqrt{2\mu}} h_1^{3/2}, s \tag{2}$$

where h_1 is the height from which the body falls, m

h_2 - height to which the body falls, m

μ- a standard gravitational parameter, m^3/s^2.

2. Equation, calculating traveled distance of falling object, thrown on sloping hill - equation (3). Graphical visualization is shown in Fig. 2.

$$R_s = \frac{2v^2 \cos^2\theta \sin\theta}{g.\cos\theta} - \tan\alpha\sqrt{1 + \tan^2\alpha}, m \tag{3}$$

where v is the initial speed with which the object is been thrown, m/s

α – angle of the hill,

θ - angle of inclination of the object (against the horizon),

g - gravity acceleration, m/s^2.

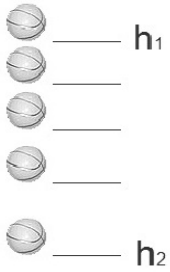

Figure 1 - Ilustration of an equation to calculate the time to fall from a height of body height h1 to h2

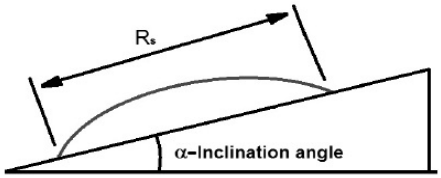

Figure 2 - Ilustration of the equation calculating the distance at which an object falls on the sloping hill cast

Standard mathematical operations, provided by each of the programming languages, are used for the calculation of the equations.

Computer languages and operating systems, covered by the study

The study covers computer language C++, C and Java. Results of pre-calculated equations are stored in generic classes mapping key to value [1, 2]. Selected structures are implemented using a hash table, which reduces the search time. Used structures are:

- for C++ – hash-map
- for Java – HashMap
- for c# – Dictionary

Computers used in this study have the following characteristics:

- Operating System – 32 bit and 64 bit Linux
- RAM – 2 to 3 GB DDR2
- CPU:
  - Cores – dual-core processors
  - CPU clock — 1.7GHz to 2,1 GHz
  - Type:
    - AMD AthlonX2 DualCore
    - Intel Pentium Dual CPU

Study Results

All presented data are rated to one million iterations.

Conclusions and future work

1. This study estimates time to find the answer of mathematical equations using a calculation and searching among a group of pre-calculated values.

2. It is appropriate to be developed an experimental platform. It will helps to study the possibilities for building applications, calculating mathematical formulas by searching the array of pre-calculated data.

References:

1. Troelsen A. Pro C 2010 and the .NET 4 Platform, 5 edition, Apress, 2010
2. Maurice N., P. Wadler. Java Generics and Collections, O'Reilly Media, 2009.