State Final Examination (Sample Questions)

Fall 2016

1 Morphological and Syntactic Analysis

1. In the context of native language processing (NLP), define what is „tagging" and „parsing".

2. Manually tag and parse the sentence „Time flies like an arrow."

3. Describe the automated tagging procedure based on Hidden Markov Models. Illustrate on the example sentence above.

4. Outline basic metrics for measuring the parsing output quality. Illustrate on the example sentence above.

2 Computer Architecture

1. Decide, as efficiently as possible, which of the following numbers are divisible by 8. Explain what you did.

    (a) 0xF13C1C50

    (b) 0x013C81C5

    (c) 0x125928FD

    (d) 0x5318C5E8

    (e) 0x831D79FF

2. Assume we have two very different algorithms that both compute a solution to the same problem. In the first algorithm, the line that is executed by far the most frequently is:

    a = b / 99;

    In the second algorithm, the line that is executed by far the most frequently, and about as frequently as in the first algorithm, is:

    a = b / 4;

    In both algorithms, a and b are unsigned integer variables of standard size and / stands for integer division.

    When the algorithms finally get to be translated into the machine code and run, which one would typically be faster and why ?

3. Assume we have an unsigned integer A of width N bits and an unsigned integer B of width M bits, N < 16 and M < 16. Assume the value of A is stored in the N low bits of a variable iA, and the value of B is stored in the M low bits of a variable iB. Other bits of both iA and iB are set to arbitrary values.

    Your task is to write a program in C# or C++ or Java that will set the value of an output variable oC such that its N low bits contain the value of A, its next M low bits contain the value of B, and the other bits are zero.

    Assume all variables are 32 bits wide.

3 Non-Procedural Programming

1. Assume the following Prolog predicates:

```
male(adam).            % adam  is  male
male(hugo).            % hugo  is  male
female(eve).           % eve  is  female
parent(adam,hugo).     % adam  is  a  parent  of  hugo
parent(eve,hugo).      % eve  is  a  parent  of  hugo

etc.
```

Write predicates father/2 and grandfather/2 with the following meaning:

```
father(Fa,Ch)         % "Fa"  is  a  father  of  "Ch"
grandfather(Gf,Ch)    % "Gf"  is  a  grandfather  of  "Ch"
```

2. How are lists defined in Prolog ?

3. Assume predicate concat/3 for concatenating two lists:

```
concat([],L,L).
concat([X|T],L,[X|S]):- concat(T,L,S).
```

What is the result of calling r(+I,-O), defined as follows (+I stands for input and -O for output) ?

```
r([],[]).
r([X|T],L):- r(T,T1), concat(T1,[X],L).
```

4. Do the following Prolog queries differ ?

```
X = 1 + 3.
X is 1 + 3.
```

4 Probability

1. Define a random real variable and its mean (expected value) over a finite probability space.

2. Formulate rules for the mean of the sum and of the product of two random real variables. Explain how these could be proved.

3. Maxmillian has three 20-cent, one 10-cent, two 5-cent, six 2-cent and three 1-cent coins (and no other).

   He draws three coins at random, all at once. Calculate the mean of the total amount he drew.

5 Vector Spaces

1. Define isomorphism between vector spaces.

2. Consider a linear mapping $f \colon U \to V$ between vector spaces U and V. Suppose that any generator set of U is mapped on a generator set of V. Is the mapping f injective ?

3. Consider the linear mapping $f \colon \mathbb{R}^3 \to \mathbb{R}^3$ defined as

$$f(a, b, c) = (a + b + c,\ 2a + c,\ 2b + c).$$

   Determine

   (a) the dimension of the image $f(\mathbb{R}^3)$,

   (b) the dimension of the kernel $Ker(f)$,

   (c) whether f is injective (one-to-one),

   (d) whether f is surjective (onto).

6 Taylor Polynomial

1. Define Taylor polynomial.

2. State some of the theorems describing the error of the approximation of a function by its Taylor polynomial.

3. Find the 5-th degree Taylor polynomial of the function $f(x) = \sin x \cdot \cos x$ on the neighborhood of 0.