

ELL457/HSL622: Minor Test II

March 24, 2023

Maximum Marks: 15

Instructions:

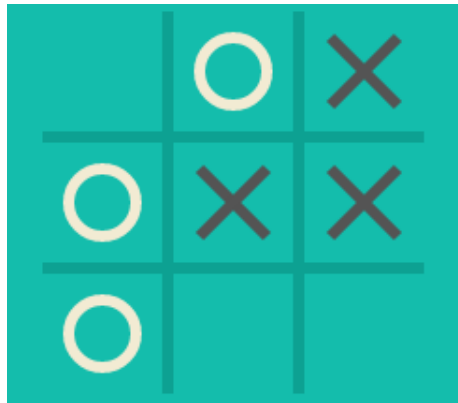
- Please clearly indicate the question number at the start of each response.
- Please read all questions carefully.
- Please ensure that your responses are to-the-point and that you write only what is asked for on the answer script you submit.
- While the exam is open-notes, all your answers must be written entirely in your own words, without any copying from anywhere.
- Please try to be clear and careful with all formal/mathematical notation, so that there is no ambiguity in the expressions/formulae you write down. Try to stick to the kind of notation used in class as far as possible.

1. We want to build a Turing Machine which takes as input a binary string (containing 0s and 1s) and outputs the *complement* of that string, i.e., changing all 0s to 1s and vice-versa. For example, if the input string is 0011101, then the output string should be 1100010. Assume that the input string is initially written onto the tape starting from the initial position of the read-write head. Please answer the following questions precisely and to-the-point.

(a) How many states do you need in the finite-state machine (FSM)? Justify your answer. Naturally, you want to choose the minimum number of states needed to carry out the required computation. Note that there should be at least one *halt* state to indicate when the computation is finished. [2]

(b) If your answer to the previous question is K (let these be denoted by $\{s_1, s_2, \dots, s_K\}$), out of which H are halt states, then draw a table with $3(K-H)$ rows and 5 columns. The first two columns should be used to list all the FSM (non-halt) state and input symbol combinations (including the blank symbol). For each such combination, in the last 3 columns you should mention, in order: the new FSM state to move to (could also be a halt state), the symbol to be written at the current head position, and the subsequent head movement (left/right/none). In other words, this table will fully specify the FSM transition function $f()$. Make sure you clearly indicate which states are halt states. [5]

2. Consider the game of *tic-tac-toe* (also called *noughts and crosses*), where there are two players each with their own assigned symbol (O or X), and they take turns entering their symbol into a chosen empty space on a 3×3 grid, with the objective being to be the first player to get three of your symbols in a straight line (horizontal, vertical, or diagonal). An example of a partially-complete game is shown below.



We would like to model the cognitive processes of a player of this game as a production system. In this regard, please answer the following questions as precisely and clearly as possible.

(a) What should the global database of the production system consist of? [2]

(b) Give *two* examples of specific production rules which the player might reasonably make use of. Please ensure your rules are if-then rules, stated exactly and unambiguously. [4]

(c) What would the control structure of the production system do, and how might it do this? Try to see if you can suggest some specific quantitative metric or algorithm it might make use of. [2]