Land Surface Process Modelling, exam, Wednesday, April 2nd, 2014, 9-12 am

Please give your answers in Dutch or English.
Each sub-question (e.g., 1a, b, etc) will approximately have the same weight in calculating your mark.

Question 1: Python programming

a) What is printed by the script in Table 1.1 (note that there are two print statements)?
b) Add statements to the script in Table 1.1 to calculate and print the sum of the values in the variable `values`. Either provide the whole script on your answer sheets or clearly explain what needs to be added or removed (and where).
c) Rewrite the script in Table 1.1 by encapsulating both 1) `a = len(values)` and 2) the while block in one function. The script should still print the same. Provide the rewritten script on your answer sheets.

```
values = [12.0, 14.0, 16.0, 12.0]

i = 0

a = len(values)

while i < a:
  b = values[i]
  print b
  i = i + 1

print type(values[1])
```

Table 1.1. Python script.

d) What is printed by the script in Table 1.2 (note that there are three print statements)?

```
import string

a = 'Amsterdam'

print a[-3:]
print a[2:4]

i = 0

b = len(a)

c = ''
while i < b:
  if a[i] == 'm':
    print a[i-1],
  i = i + 1
```

Table 1.2. Python script

Question 2: PCRaster Python

Somebody wants to construct a dynamic model calculating the amount of soil water erosion (m^3/m^2) as a result of surface runoff. The amount of soil erosion s_t (m^3/m^2) at time step t is calculated as:

$$s_t = a q_t s$$

with a, a parameter; q_t, the surface runoff (m^3) at time step t; and s the slope gradient of the surface (m/m). The time step duration is one hour, the model is run for 10 hours (10 time steps), and a rainfall map (m) with total rainfall over a time step is available for each time step. A digital elevation model is available to calculate flow directions. The cell size is 100 m^2. We can assume no rainfall is intercepted by the vegetation and zero infiltration into the soil.

Table 2.1 provides an empty PCRaster Python script.

a) Add statements to the script to calculate (and write to disk) a map with q_t for each time step. Explain where you put the statements. If you can't remember the name of PCRaster functions, just make up one yourself and explain what it does.
b) Add statements to the script to calculate (and write to disk) a map with s_t for each time step. Explain where you put the statements.

```
from pcraster import *
from pcraster.framework import *

class MyFirstModel(DynamicModel):
  def __init__(self):
    DynamicModel.__init__(self)
    setclone('dem.map')

  def initial(self):
    pass

  def dynamic(self):
    pass

nrOfTimeSteps=10
myModel = MyFirstModel()
dynamicModel = DynamicFramework(myModel,nrOfTimeSteps)
dynamicModel.run()
```

Table 2.1. Empty PCRaster Python script for dynamic modelling.

Question 3. Agent-based modelling

This agent-based model (Figure 1 and Figure 2) simulates the behaviour of two types of turtles in a pond. Each turtle wants to make sure that it lives near 70% of 'its own.' That is, each white turtle requires at least 70% of its surrounding neighbours in the Moore neighbourhood to be white turtles and each grey turtle requires at least 70% of its surrounding neighbours in the Moore neighbourhood to be grey turtles.

By clicking the SETUP button, the initial distribution of the turtles (arrow-like shapes) is defined, which is a random distribution throughout the pond. There are equal numbers of white and grey turtles. In each 'tick', the turtles jump to a random nearby empty patch when they do not have 70% same-colour neighbours.

The % SIMILAR window shows the average percentage of same-colour neighbours for each turtle. It starts at about 50%, since each turtle starts (on average) with an equal number of white and grey turtles as neighbours. The % UNHAPPY monitor shows the percent of turtles that have fewer same-colour neighbours than they want (and thus want to move).

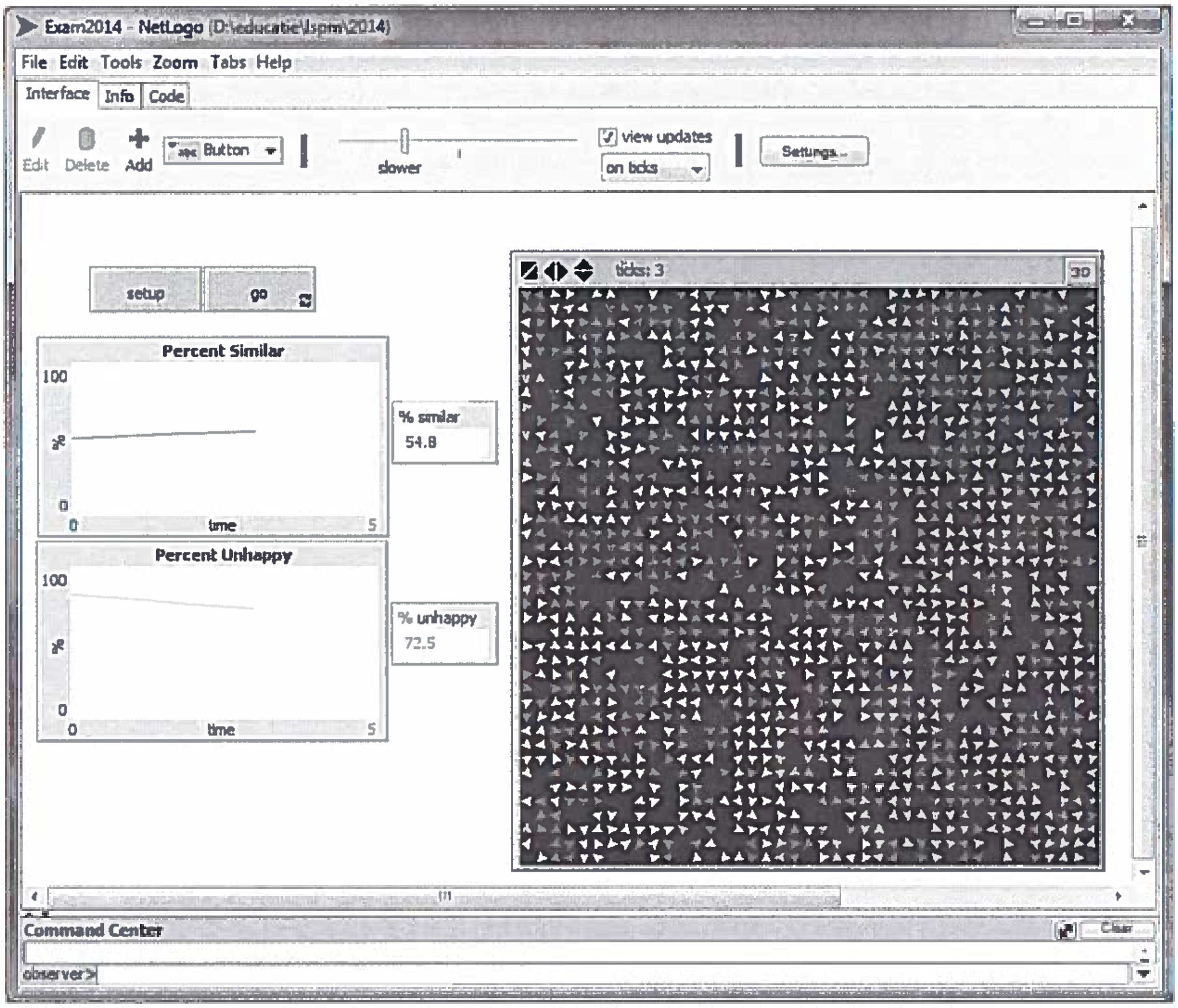

Figure 1: Screenshot of the agent-based model of turtles in a pond after 3 ticks.

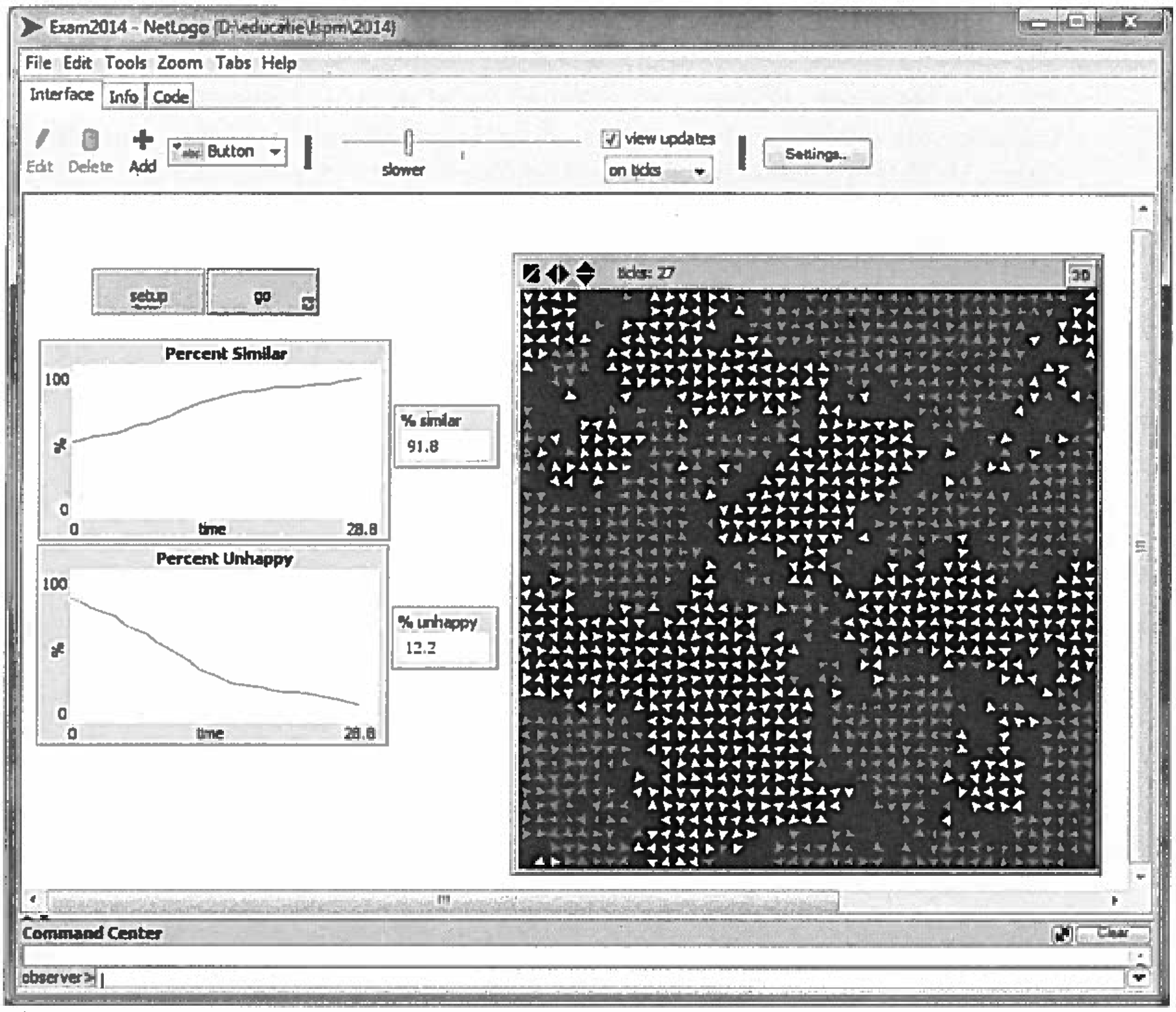

Figure 2: Screenshot of the agent-based model of turtles in a pond after 14 ticks.

a) Give four characteristics of an agent and identify these characteristics in the model described above. So only name agent characteristics that can be found in this model.
b) Over time, the number of unhappy turtles decreases, and the pond becomes more segregated, with clusters of white turtles and clusters of grey turtles. Explain why the exact final configuration of segregation in the model is path-dependent.

Question 4

To study vegetation dynamics, a numerical model needs to be developed simulating the temporal evolution of the spatial distribution of two vegetation communities (grass, shrubs) in a natural area. From field observations, it is clear that the shrub area gradually extends, mainly through clonal growth (i.e. growth of existing shrubs into neighbouring grass areas).

a) Explain how a cellular automata model could be constructed representing this system. Give a clear description of the transition rule(s) (applied each time step) that would be used.

As a next step, the model needs to be calibrated. Maps are available giving the spatial distribution of the vegetation in 1970, 1975, and 1980. This information can be used for calibration.

b) Provide a goal function (i.e. objective function or performance measure) that could be used in the calibration. Either give it as an equation or clearly explain in words how it is calculated.
c) Explain how you would calibrate the model using the brute force technique.