Turing Machine Simulator

The world's first Turing Machine Simulator for
HP calculators developed by Erwin H. Ried

0. Summary

1. Introduction

1.1 Formal reference

Turing machines are extremely basic symbol-manipulating devices which — despite their simplicity — can be adapted to simulate the logic of any computer that could possibly be constructed. They were described in 1936 by Alan Turing. Though they were intended to be technically feasible, Turing machines were not meant to be a practical computing technology, but a thought experiment about the limits of mechanical computation; thus they were not actually constructed. Studying their abstract properties yields many insights into computer science and complexity theory.

A Turing machine that is able to simulate any other Turing machine is called a universal Turing machine (UTM, or simply a universal machine). A more mathematically-oriented definition with a similar "universal" nature was introduced by Alonzo Church, whose work on lambda calculus intertwined with Turing's in a formal theory of computation known as the Church–Turing thesis. The thesis states that Turing machines indeed capture the informal notion of effective method in logic and mathematics, and provide a precise definition of an algorithm or 'mechanical procedure'.[1]

[1] http://en.wikipedia.org/wiki/Turing_machine

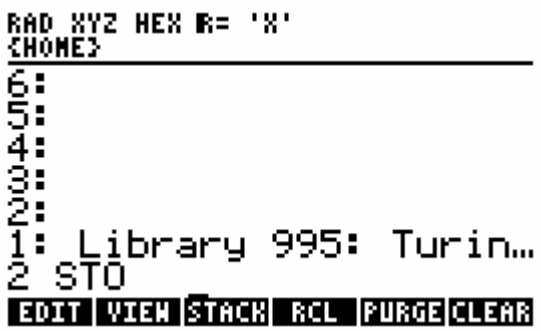
2 Installing the simulator

2.1 Preliminaries

Of course, you need one HP Calculator or at least Emu48 running a 49g+ ROM. The following devices are supported: HP49g, HP49g+[2] and HP50g. The HP48 series are not supported because the lack of a powerful processor and some UserRPL commands.

2.2 How to install

Copy the library file to any available port *(see Screenshot 1)* and then attach the library rebooting your calculator.



Screenshot 1— Installing the library on port 2

[2] Original HP49g+ ROM and ROM version 2.0 or newer are supported

3 The language

3.1 Basics

Syntax	Meaning	Example
`;comment`	Comment, ignored by the simulator	`;this is a comment`
	Blank line, just for readability	
`B:B`	Empty tape symbol. This statement is optional, if not defined the simulator will use "B" as empty tape. This must be a single letter symbol, can be a space	`B:X`
`q0:state`	Initial state. Machine will start with this state. This statement is optional, if not defined the simulator will use "q0" as initial state	`q0:qinitial`
`qf:state`	Final state. Machine will accept a string only if the final state is reached. This statement is optional, if not defined the simulator will use "qf" as final state	`qf:qfinal`
`qn,tape:qn!,tape!,dir`	Statement definition. Machine at state "qn" and with the "tape" symbol will change to "qn!" state, replacing the "tape" symbol with "tape!" and moving the head to "dir", where "dir" is "<" or ">" for left or right	`q1,A:q2,B,>`

3.2 Rules

- ✓ Tape symbol and empty tape symbol must have a length of one character only
- ✓ If any state is undefined, automatically the input string will be rejected by the Turing Machine
- ✓ The input string is only accepted if the machine reaches a final state. Final state must not be defined as statement definition like other states of the machine
- ✓ Only one statement or line break is supported per each line, therefore you cannot mix comments and other statement like an initial state definition for example

4 Your first Turing Machine

4.1 Example machine

In this example, the main purpose is taught about how to use the simulator. First, there are the conditions of this Turing Machine:

Action	**Data (Unary[3])**	**Example**
Input	0^n	0, 000, ...
Output	0^{3n}	000, 000000000, ...

In other words, this machine will returns the input multiplied by 3

```
;Turing Machine Example
;
;This machine outputs 0^3n
;for 0^n as input

;Empty will be letter E
B:E

;Initial state
q0,0:q1,X,<
q0,E:q3,E,>
q0,Y:q0,Y,<

q1,0:q1,0,<
q1,E:q2,Y,>
q1,Y:q1,Y,<

q2,0:q2,0,>
q2,E:q0,Y,<
q2,X:q2,Y,>
q2,Y:q2,Y,>

q3,E:q4,E,<
q3,Y:q3,0,>

;Final status def.
qf:q4

;Initial status will
;be default (q0)

;End
```

[3] Base-1 or unary is the simplest numeral system to represent natural numbers

4.2 Executing the machine

Save the code as String and then invoke the simulator with the following parameters in the same order:

```
BEGIN(“PROGRAM”, “INPUT”, [DELAY])
```

DELAY must be a number from zero to infinite and can be omitted. If you set a delay of zero, the simulator will not show the graphical simulation of the tape. For example if you want to hide the tape animation, set DELAY to zero. If you want to freeze the tape motion for a half of second, set DELAY to 0.5 (secs).

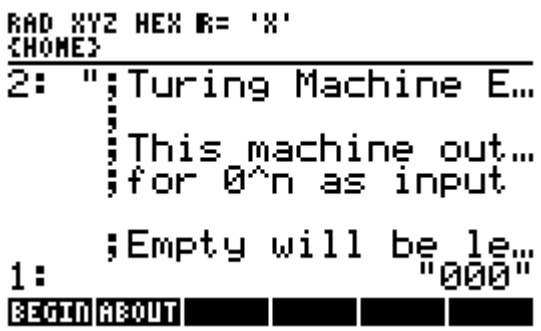
In RPN mode, the invocation is the same:

```
3: “PROGRAM”
2: “INPUT”
1: [DELAY]
BEGIN
```

The following will set a default delay, this works only if there are two elements in the stack before calling the BEGIN function:

```
2: “PROGRAM”
1: “INPUT”
BEGIN
```

After press ENTER, the simulator will begin the execution of the machine with the input tape *(see Screenshot 3*— **In middle of the simulation***)*.



Screenshot 2— Pressing BEGIN will start the simulation

Screenshot 3— In middle of the simulation

5 Reference

5.1 About Alan Turing

Alan Turing (June 23, 1912 – June 7, 1954) was an English mathematician, logician, and cryptographer. Turing is often considered the father of modern computer science.

With the Turing test, Turing made a significant and characteristically provocative contribution to the debate regarding artificial intelligence: whether it will ever be possible to say that a machine is conscious and can think. He provided an influential formalization of the concept of algorithm and computation with the Turing machine, formulating the now widely accepted "Turing" version of the Church–Turing thesis, namely that any practical computing model has either the equivalent or a subset of the capabilities of a Turing machine. During World War II, Turing worked at Bletchley Park, Britain's code breaking centre and was for a time head of Hut 8, the section responsible for German Naval cryptanalysis. He devised a number of techniques for breaking German ciphers, including the method of the bombe, an electromechanical machine which could find settings for the Enigma machine.

After the war, he worked at the National Physical Laboratory, creating one of the first designs for a stored-program computer, although it was never actually built. In 1947 he moved to the University of Manchester to work, largely on software, on the Manchester Mark I then emerging as one of the world's earliest true computers.

In 1952, Turing was convicted of acts of gross indecency after admitting to a sexual relationship with a man in Manchester. He was placed on probation and required to undergo hormone therapy. When Alan Turing died in 1954, an inquest found that he had committed suicide by eating an apple laced with cyanide. [4]

[4] http://en.wikipedia.org/wiki/Alan_Turing