

程序代写代做 CS编程辅导

FIT2014 Theory of Computation



Lecture 19

Universal Turing Machines

WeChat: cstutorcs

Assignment Project Exam Help

slides by Graham Farr

Email: tutorcs@163.com

based in part on previous slides by David Albrecht

QQ: 749389476

COMMONWEALTH OF AUSTRALIA
<https://tutorcs.com>

Copyright Regulations 1969

Warning

This material has been reproduced and communicated to you by or on behalf of Monash University
in accordance with s113P of the Copyright Act 1968 (the Act).

The material in this communication may be subject to copyright under the Act.

Any further reproduction or communication of this material by you may be the subject of copyright protection under the Act.

Do not remove this notice.

Overview

程序代写代做 CS编程辅导



- ▶ Tables for Turing Machine
- ▶ Encoding
- ▶ Decoding
- ▶ Definition of a Universal Turing Machine
- ▶ Algorithm for a Universal Turing Machine
- ▶ Existence of Universal Turing Machines

WeChat: cstutorcs

Assignment Project Exam Help

Email: tutorcs@163.com

QQ: 749389476

<https://tutorcs.com>

Assumptions

程序代写代做 CS编程辅导



► Input Alphabet: $\{a,b\}$

► Tape Alphabet: $\{a,b,\#\}$ WeChat: cstutorcs

► Start State: numbered 1

► Accept State: numbered 2

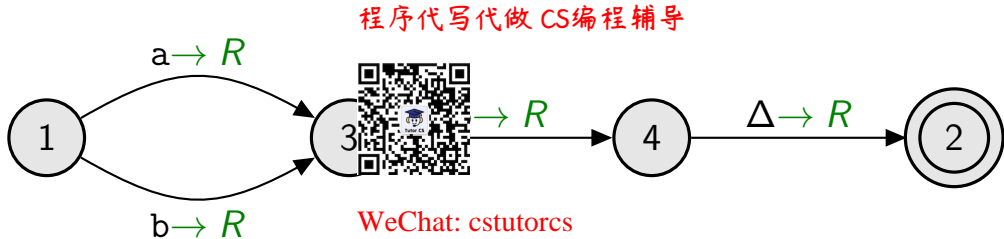
Assignment Project Exam Help

Email: tutorcs@163.com

QQ: 749389476

<https://tutorcs.com>

Tables for TMs



Assignment Project Exam Help

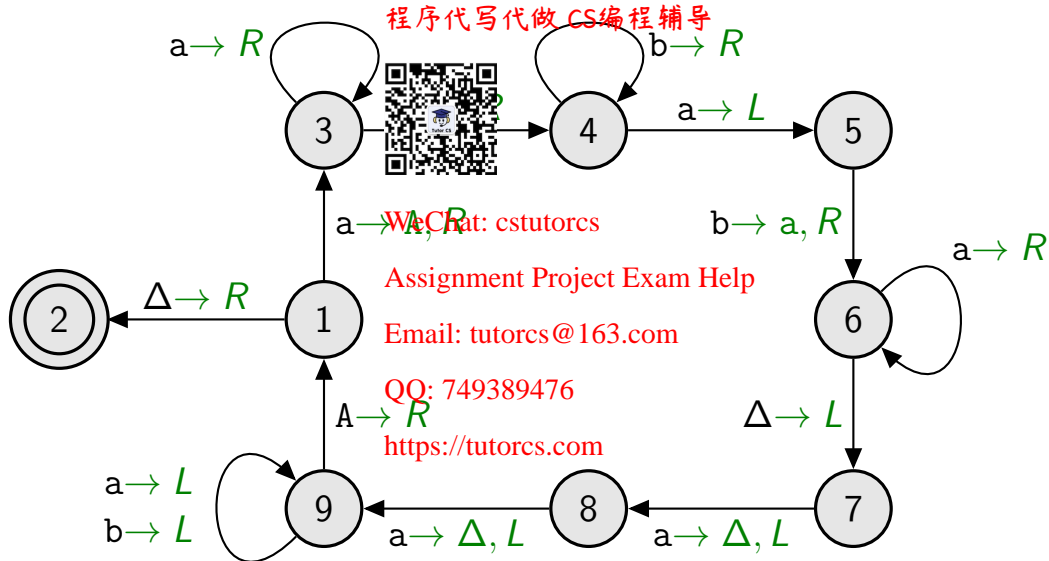
Email: tutorcs@163.com

QQ: 749389476

<http://tutorcs.com>

From	To	Read	Write	Move
1	3	a	a	R
1	3	b	b	R
3	4		b	R
4	2	Δ	Δ	R

TM for $\{a^n b^n a^n : n \geq 0\}$



Table

From	To	Read	Write	Move
1	3	a	#	R
3	3	a	a	
3	4	b	b	
4	4	b	b	
4	5	a	a	
5	6	b	a	R
6	6	a	a	R
6	7	Δ	Δ	L
7	8	a	Δ	L
8	9	a	Δ	L
9	9	a	a	L
9	9	b	b	L
9	1	#	#	R
1	2	Δ	Δ	R

程序代写代做 CS编程辅导

WeChat: cstutorcs

Assignment Project Exam Help

Email: tutorcs@163.com

QQ: 749389476

<https://tutorcs.com>

Conditions to Check

程序代写代做 CS编程辅导



Check whether there is a row with a 1 in the From column.

Check that there is no row with a 2 in the From column.

Check there are no two rows with the same numbers in the From and the same letter in the Read column.

Assignment Project Exam Help

Email: tutorcs@163.com

QQ: 749389476

<https://tutorcs.com>

Coding

程序代写代做 CS编程辅导



State	Code
number	$a^n b$

Letter	Code
a	aa

Assignment Project Exam Help

Email: tutorcs@163.com

QQ: 749389476

Direction	Code
L	a
R	b

Coding the Table

From	To	Read	Write	Move	Code
1	3	a	#	R	abaaabaabbb
3	3	a	a	R	abaaabaaaab
3	4	b	b	R	abaaaabababb
4	4	b	b	R	abaaaabababb
4	5	a	a	L	aaaabaaaaabaaaaa
5	6	b	a	R	aaaaabaaaaaababab
6	6	a	a	R	aaaaaabaaaaaabaab
6	7	Δ	Δ	L	aaaaaabaaaaaabbabaa
7	8	a	Δ	L	aaaaaabaaaaaabaabaa
8	9	a	Δ	L	aaaaaaaabaaaaaaaaabaabaa
9	9	a	a	L	aaaaaaaaabaaaaaaaaabaaaaa
9	9	b	b	L	aaaaaaaaabaaaaaaaaabababa
9	1	#	#	R	aaaaaaaaababbbbbbb
1	2	Δ	Δ	R	abaabbabab

程序代写代做 CS编程辅导



WeChat: cstutorcs

Assignment Project Exam Help

Email: tutorcs@163.com

QQ: 749389476

<https://tutorcs.com>

Encoding of the TM

程序代写代做 CS编程辅导

[illegible]

...as one long string, without breaks or spaces.

Email: tutorcs@163.com

QQ: 749389476

<https://tutorcs.com>

Code Word Language (CWL)

The **Code-Word Language (CWL)** is the regular language defined by the regular expression



$a^*b(a \cup b)^5)^*$

Words which encode a TM belong to CWL.

BUT: **Not** all words in CWL encode a TM.

Quantifier practice:

- $\neg \forall w \in \text{CWL} \quad \exists M : w \text{ encodes } M$
- $\exists w \in \text{CWL} \neg \exists M : w \text{ encodes } M$
- $\exists w \in \text{CWL} \forall M : (w \text{ encodes } M)$
- $\exists w \in \text{CWL} \quad \forall M : w \text{ does not encode } M$

Decode

程序代写代做 CS编程辅导



abaaabaaaabababababbaaa oabbbaaabaabbabab

From	To	Read	Write	Move
1	3	a	a	R
1	3	b	b	R
3	4	b	b	R
4	2	Δ	Δ	R

WeChat: cstutorcs

Assignment Project Exam Help

Email: tutorcs@163.com

QQ: 749389476

<https://tutorcs.com>

Algorithm

程序代写代做 CS编程辅导

While there are unread letters



1. Read and count the next clump of a's, then read the b after it.
 - ▶ Interpret clump of a's as the state number, in unary, that this transition goes from.
2. Read and count the next clump of a's, then read the b after it.
 - ▶ Interpret clump of a's as the state number, in unary, that this transition goes to.
3. Read the next two letters.
 - ▶ Interpret it as the letter to be read for this transition.
4. Read the next two letters.
 - ▶ Interpret it as the letter to be written for this transition.
5. Read the next letter.
 - ▶ Interpret it as the direction for this transition.

Website: tutorcs.com

Assignment Project Exam Help

Email: tutorcs@163.com

QQ: 749389476

<https://tutorcs.com>

Universal Turing Machine (UTM)

程序代写代做 CS编程辅导



Definition

A **Universal Turing Machine (UTM)** is a Turing Machine that takes, as input,

- ▶ an encoding of some Turing Machine M , together with
- ▶ a string x , to be used as input to M

and simulates the execution of M on x .

WeChat: cstutorcs

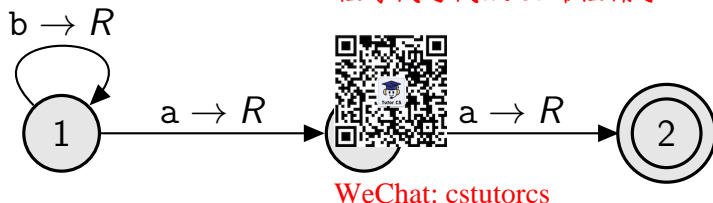
Assignment Project Exam Help

Email: tutorcs@163.com

QQ: 749389476

<https://tutorcs.com>

Example



Assignment Project Exam Help

Suppose we want a UTM to simulate the execution of this TM on the string bbbaa.

Email: tutorcs@163.com

Input to the UTM:

QQ: 749389476

Turing Machine: abaaabaaaabababababbbaaabaabaaaab

Data: bbbaa

<https://tutorcs.com>

Input for UTM

程序代写代做CS编程辅导

input for the UTM

Turing Machine (encoded)

input for the encoded TM

a b a a a b a a a b a b a b a b a b b a b a a a b a a a a b \$ b b b a a $\Delta\Delta\Delta\cdots$

WeChat: estutorcs

Assignment Project Exam Help

Email: tutorcs@163.com

QQ: 749389476

<https://tutorcs.com>

marks end of
TM encoding
and start of
its input

Algorithm for a UTM

1. Move rightwards to first letter of the encoded TM's input.
Read it. Mark it, so we can come back to it (e.g., $a \mapsto A$, $b \mapsto B$).
 - ▶ Remember it (in choice of state).
2. Move leftwards to first instruction in encoded TM.
3. If the next state in current instruction in encoded TM is the Accept state
Find (from current instruction) what to write and direction of next move.
Remember it (in choice of state).
Move rightwards back to current position in encoded TM's input.
Write the required letter, move in the required direction and Accept.
else
Find (from current instruction) what to write and direction of next move.
Remember it (in choice of state).
Move rightwards back to current position in encoded TM's input.
Write the required letter, move in the required direction.
Read current letter in encoded TM's input. Mark it, so we can come back to it.
Remember it (in choice of state).
Move leftwards to find the next instruction (using remembered letter).



WeChat: cstutorcs

Assignment Project Exam Help

Email: tutors@163.com

QQ: 749389476

https://tutors.cn

Exercise

程序代写代做 CS编程辅导

Suppose:

- ▶ U is a UTM,
- ▶ T is a TM
- ▶ x is an input string for T , with $|x| = n$.
- ▶ When T is run on input x , it takes time t and visits at most s tape cells.



WeChat: cstutorcs

Assignment Project Exam Help

Using the algorithm outline of the previous slide, and the encoding scheme for TMs given in this lecture:

Email: tutorcs@163.com

- ▶ Determine an upper bound for the time taken by U to simulate the running of T on input x .
- ▶ Give the bound in terms of t , s and n .

QQ: 749389476

<https://tutorcs.com>

Importance of UTMs

程序代写代做 CS编程辅导



- ▶ theoretical model of one computer simulating another
- ▶ Stored-program computer
- ▶ von Neumann architecture

WeChat: cstutorcs

Assignment Project Exam Help

Email: tutorcs@163.com

QQ: 749389476

<https://tutorcs.com>

Revision

程序代写代做 CS编程辅导



- ▶ Know how to encode a Turing machine.
- ▶ Know how to decode Turing Machine representation.
- ▶ Know what a Universal Turing Machine is, and what it does.
- ▶ Understand why UTMs exist.

Email: tutorcs@163.com

QQ: 749389476

<https://tutorcs.com>