## KAZAKH NATIONAL UNIVERSITY NAMED AFTER AL-FARABI

D.R. Rakhimova, Zh.M. Zhumanov

# MACHINE TRANSLATION TECHNOLOGIES

Electronic Textbook

Almaty
"Kazakh University"
2022

UDC 80/81 LBC 81.2 R15

> Recommended for publication by the Academic Council Faculty of Information Technology and RISO of Al-Farabi KazNU (Protocol No. 1 of 9.10.2021)

#### **Reviewers:**

O.Zh. Mamyrbaev – PhD., associate professor. Deputy General Director RSE "Institute of Information and computing technologies" M.E. Mansurova – PhD., assistant professor, Head of the department "Artificial Intelligence and Big Data" Al-Farabi KazNU

### Rakhimova D.R., Zhumanov Zh.M.

R 15 Machine translation technologies: electronic textbook / D.R. Rakhimova,Zh.M. Zhumanov. – Almaty: Kazakh University, 2022. – 180 p.

ISBN 978-601-04-6046-1

The tutorial describes systems and modern methods of machine translation for natural language. The manual can be used for undergraduate, graduate and doctoral students of the specialties "Information Systems", "Information Security Systems", "Informatics". This tutorial can be used for graduate and master's theses in computational linguistics and artificial intelligence.

Acknowledgments.

This works was performed by the grant Project IRN AP 08052421 of Ministry of Science and Higher Education of the Republic of Kazakhstan and Erasmus CLASS Project "Development of the interdisciplinary master program on Computational Linguistics at Central Asian universities" Number 585845-EPP-1-2017-1-ES-EPPKA2-CBHE-JP

UDC 80/81 LBC 81.2

## **Contents**

Introduction	4
Chapter 1. Overview and Architectures of machine translation system	
1.1. Overview of machine translation problems	5
1.2. Architectures of machine translation systems	11
1.3 Practical work	17
Chapter 2. Rule-based machine translation	19
2.1. Basic concepts of RBMT. Overview of resources needed for RBMT	19
2.2. RBMT models. Apertium machine translation platform	28
2.3. Practical work	41
Chapter 3. Statistical machine translation	43
3.1. Basic concepts of SMT. Overview of resources needed for SMT	43
3.2. SMT models: Word-Based Models. Phrase-Based Models. Decoding	49
3.3. Practical work	72
Chapter 4. SMT models	73
4.1. Language Models. Tree-Based Models	73
4.2. Moses statistical machine translation system	95
4.3. Practical work	110
4.5. Hactical Work	110
Chapter 5. Hybrid machine translation	112
5.1. Applications of Machine Translation	112
5.2. Practical work	119
Chapter 6. Neural machine translation	120
6.1. The basic concepts, principle of operation and review of approaches	120
6.2. Neural Machine Translation with TensorFlow	130
6.3. Practical work	143
Chapter 7. Neural machine translation models	147
7.1. Neural Machine Translation using an Attention Mechanism	147
7.2. Neural machine translation using a Transformer model	155
7.3. Practical work	162
Chapter 8. Evaluation of Machine Translation Systems	166
8.1.Review of Evaluation methods of Machine Translation Systems	166
8.2.Practical work	169
	107
Chapter 9. Post-editing system in machine translation	173
>	173
9.2 Test runs and evaluation of the translation quality of the post-editing	
system prototype	178