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ISSUES OF AUTOMATIC PROCESSING OF WORD COMBINATIONS IN BUILDING ENGLISH-UZBEK ELECTRONIC DICTIONARIES

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Abstract: This research paper addresses the fundamental theoretical and practical problems associated with the automatic processing of multi-word combinations (MWCs), collocations, idiomatic expressions, and phrasal verbs in the context of building high-precision English-Uzbek electronic dictionaries and computational lexicography systems. Due to structural, typological, and genealogical differences between English (an Analytic/Indo-European language) and Uzbek (an Agglutinative/Turkic language), direct word-for-word statistical and rule-based translations fail to achieve high accuracy. This thesis examines syntactic alignment algorithms, semantic dependency parsing, morphological synthesis of Uzbek target structures, statistical association measures (PMI, LLR, t-score), and hybrid deep learning models (Transformer-based architecture with fine-tuning). A systematic methodology for compiling, filtering, and structuring bilingual collocations is proposed alongside an evaluation of translation disambiguation metrics.

Keywords: Computational Linguistics, English-Uzbek Electronic Dictionaries, Multi-Word Expressions (MWE), Automatic Processing, Natural Language Processing (NLP), Agglutinative Morphology, Lexicography.

1. INTRODUCTION AND THEORETICAL BACKGROUND

In modern computational linguistics, the creation of robust bilingual electronic dictionaries and machine translation (MT) systems requires handling linguistic structures beyond single-word tokens. While unigram lexical retrieval has reached high precision through automated lexicon lookup, multi-word units—such as collocations, idioms, phrasal verbs, compound nouns, and fixed formulas—present persistent challenges. The dynamic nature of natural language dictates that the total semantic value of a word combination is often non-compositional, meaning it cannot be deduced simply from the sum of its individual components.

When engineering English-Uzbek electronic lexicographical systems, developers encounter severe structural asymmetry. English is predominantly an analytic language belonging to the Germanic branch of the Indo-European family, characterized by fixed Word Order (SVO - Subject-Verb-Object), extensive prepositions, and analytical verb forms. In contrast, Uzbek is a highly synthetic, agglutinative language belonging to the Karluk branch of the Turkic family, characterized by flexible Word Order

with a strong preference for SOV (Subject-Object-Verb), rich nominal and verbal suffixation, and postpositional structures.

Consequently, the automatic extraction, parsing, semantic alignment, and morphological generation of word combinations between English and Uzbek require sophisticated Natural Language Processing (NLP) pipelines. This thesis investigates the architectural, linguistic, and algorithmic solutions necessary to address these complexities effectively.

2. TYPOLOGICAL ASYMMETRY AND CLASSIFICATION OF WORD COMBINATIONS

To establish a systematic approach for automatic processing, multi-word combinations in English must be classified based on their level of compositionality, syntactic flexibility, and target translation mapping in Uzbek.

2.1. Structural Classification of Multi-Word Units

- **Free Word Combinations (Compositional):** Modifiers and heads maintain their literal senses (e.g., "heavy rain" → "shiddatli yomg'ir"). These can be parsed via standard syntactic rule patterns.
- **Semi-Fixed Collocations (Semi-Compositional):** Words that frequently co-occur with constrained lexical choices (e.g., "make a decision" → "qaror qabul qilmoq" / "qaror qilmoq", where English relies on a light verb construct and Uzbek uses a compound verb or noun-verb conjugation).
- **Fixed Idiomatic Expressions (Non-Compositional):** Units whose meaning is completely non-derivable from individual components (e.g., "kick the bucket" → "vafot etmoq" / "olamdan o'tmoq"). Word-for-word processing yields incorrect outputs like "paqirni tepmoq".
- **Phrasal Verbs & Prepositional Verbs:** English verb + particle structures that map onto single agglutinated verb roots or auxiliary verb constructions in Uzbek (e.g., "look forward to" → "intizorlik bilan kutmoq"; "give up" → "taslim bo'lmoq" / "voz kechmoq").

English Category	English Structure	Uzbek Structural Equivalent	Computational Mapping Type
Noun Phrase (NP)	Adj + Noun (e.g., artificial intelligence)	Noun + Noun / Adj + Noun (sun'iy intellekt)	Direct 1:1 or 2:1 Tag Alignment
Verb Phrase (VP)	Verb + Noun Obj (e.g., take responsibility)	Noun + Auxiliary Verb (mas'uliyatni o'z zimmasiga olmoq)	Re-ordering (SVO → SOV) + Case Suffix
Phrasal Verb	Verb + Particle + Prep (e.g., catch up with)	Single Verb Stem + Affixation (yetib olmoq)	Multi-token Collapse → Target Stem
Prepositional Phrase	Prep + Noun (e.g., in front of the building)	Noun + Genitive + Postposition/ Locative (binoning oldida)	Preposition-to-Postposition Conversion

As illustrated above, successful automatic processing cannot rely on static word-level indexing. Instead, electronic dictionaries must integrate multi-token indexing, dependency parsing, and deep morphological synthesis.

3. MATHEMATICAL AND STATISTICAL METHODS FOR COLLOCATION EXTRACTION

Building comprehensive English-Uzbek electronic dictionaries requires harvesting collocations and word combinations from large parallel and comparable corpora (such as news corpora, literary translations, and legal texts). Automatic Extraction relies on statistical association measures combined with Part-of-Speech (POS) filtering.

3.1. Association Measures in Bilingual Lexicography

To distinguish true collocations from accidental co-occurrences of tokens, statistical metrics are calculated over candidate n-grams. The three primary metrics used in our processing system are:

1. Pointwise Mutual Information (PMI): Quantifies the discrepancy between the probability of their coincidence and the probability of individual occurrences.

$$\mathbf{PMI}(w_1, w_2) = \log_2 (P(w_1, w_2) / [P(w_1) \cdot P(w_2)])$$

2. Dice Coefficient: Measures the harmonic co-occurrence density of bigrams across parallel text fragments.

$$\mathbf{Dice}(w1, w_2) = (2 \cdot f(w_1, w_2)) / (f(w_1) + f(w_2))$$

3. Log-Likelihood Ratio (LLR): Provides robust evaluation for low-frequency lexical pairs in specialized or domain-specific corpora.

3.2. POS Filtering and Syntactic Rules

Raw statistical extraction yields high noise due to high-frequency function words (articles, conjunctions). Therefore, regular expression filters over POS tag sequences are implemented before calculating association metrics:

- NP_Pattern_1 = (JJ | NN) + NN → e.g., "computational linguistics"
- VP_Pattern_1 = VB + (DT)? + JJ* + NN → e.g., "play an important role"
- PP_Pattern_1 = IN + DT? + NN + IN → e.g., "with respect to"

4. ALGORITHMIC FRAMEWORK FOR ENGLISH-UZBEK WORD COMBINATION PROCESSING

The core engine of an advanced English-Uzbek electronic dictionary operates on a modular multi-stage processing pipeline. The architecture guarantees that when a user inputs a query containing a multi-word phrase, the system correctly identifies whether it should be parsed as a cohesive unit or disassembled syntactically.

4.1. Morpho-Syntactic Analysis and Token Alignment

The processing workflow consists of six essential pipeline stages:

1. **Tokenization and Lemmatization:** Input sentences or expressions are normalized into base forms (lemmas).

2. **Multi-word Unit Boundary Detection:** Utilizing Aho-Corasick string matching and Trie data structures to match input n-grams against the electronic dictionary's index of multi-word entries.

3. **Syntactic Parsing:** Generating dependency trees to locate head words and dependent modifiers (e.g., identifying that in "make a significant breakthrough", "breakthrough" is the direct object of "make").

4. **Bilingual Mapping and Reordering:** Mapping source dependency patterns into target Uzbek structural rules.

The English pattern Verb + Direct Object is inverted to Uzbek Object + Verb.

5. **Agglutinative Morphological Generation:** Uzbek target words require appropriate case endings, possessive suffixes, and verbal inflections. For instance, the direct object requires the Accusative case suffix ("-ni") or Indefinite Genitive depending on context.

6. **Semantic Disambiguation:** Resolving polysemous word combinations using context embeddings (e.g., BERT/mBERT vector similarity).

Input Phrase (English)	Syntactic Dependency Structure	Uzbek Base Translation	Morphological Generation & Output
"pay attention to"	pay [head] → attention [obj] → to [prep]	e'tibor qaratmoq	**e'tibor qaratmoq** (Dative alignment integrated)
"solve the complicated problem"	solve [verb] → problem [obj] → complicated [adj]	murakkab muammo + yechmoq	**murakkab muammoni hal qilmoq / yechmoq** (Accusative suffix -ni added)
"under extreme environmental conditions"	under [prep] → conditions [pobj] → extreme, environmental [amod]	favqulodda atrofmuhit sharoitlari + ostida	**favqulodda atrof-muhit sharoitlarida** (Locative suffix da synthesis)

5. MORPHOLOGICAL GENERATION CHALLENGES IN UZBEK TARGET EQUIVALENCE

One of the primary bottlenecks in automatic bilingual lexicography involving Turkic languages is the phenomenon of morphological explosion. While English modifies meaning primarily through word order and auxiliary particles, Uzbek modifies meaning through concatenative suffixation.

5.1. Case Agreement and Postpositional Synthesis

In English word combinations, prepositions establish spatial, temporal, and casual relationships. In Uzbek, these are expressed either through six grammatical cases or via postpositions (ko'makchilar):

- **Nominative (Bosh kelishik):** Zero suffix (Ø)
- **Genitive (Qaratqich kelishik):** Suffix -ning (expresses possession in noun combinations: e.g., "system of language" → "tilning tizimi")
- **Dative (Yönnalish kelishik):** Suffix -ga / -ka / -qa (direction/purpose: e.g., "lead to success" → "muvaffaqiyatga olib kelmoq")
- **Accusative (Tushum kelishik):** Suffix -ni (definite direct object: e.g., "read the book" → "kitobni o'qimoq")
- **Locative (O'rin-payt kelishik):** Suffix -da (location/time: e.g., "at the university" → "universitetda")

• **Ablative (Chiqish kelishik):** Suffix -dan (source/origin: e.g., "result from errors" → "xatolardan kelib chiqmoq")

Electronic dictionaries must embed rule engines or finite-state transducers (FST) capable of appending correct vowel-harmony-compliant affixes to target Uzbek phrases when presenting example usages or generating automatic translations.

5.2. Handling Verb System Transformations

Phrasal verbs represent another major structural challenge. Consider the English verb "to look" when combined with various particles:

- Look after: → g'amxo'rlik qilmoq / qaramog'iga olmoq
- Look for: → qidirmoq / izlamoq
- Look up to: → hurmat qilmoq / havas qilmoq
- Look down on: → mensimaslik / past nazar bilan qaramoq

A simple dictionary lookup that treats "look" independently will result in total semantic breakdown. The electronic dictionary engine must employ continuous token window parsing (up to 4 tokens apart) to detect noncontiguous phrasal verbs (e.g., "look the word up").

6. SEMANTIC DISAMBIGUATION AND CONTEXTUAL EMBEDDINGS

Polysemy in multi-word combinations occurs when a phrase carries different translations depending on the domain (e.g., medical, legal, information technology, general speech).

6.1. Contextual Vector Models (mBERT & XLM-RoBERTa)

Modern electronic dictionaries are increasingly hybrid systems—combining classical lexicographical databases with neural contextual embeddings. By utilizing multilingual Transformers such as mBERT or XLM-RoBERTa, the electronic dictionary system can compute semantic similarity vectors to select the correct Uzbek entry for polysemous expressions.

For example, consider the phrase "run out of":

• **Context A (Resource depletion):** "We ran out of time." → Uzbek translation: "Vaqtimiz tugadi."

• **Context B (Physical movement):** "He ran out of the room." → Uzbek translation: "U xonadan yugurib chiqdi."

By comparing the cosine distance between the input sentence context vector **V** and canonical sense **input** vectors **S , S** stored in the dictionary backend, the optimal Uzbek translation equivalency is automatically

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retrieved:

$$\text{Sense} = \underset{k}{\text{argmax}} \left(\cos\left(V_{input}, S_k \right) \right) = \underset{k}{\text{argmax}} \left(\left[V_{input} \cdot S_k \right] / \left[\|V_{input}\| \cdot \|S_k\| \right] \right)$$

7. DATABASE ARCHITECTURE FOR BILINGUAL ELECTRONIC DICTIONARIES

To ensure real-time query execution (< 50ms) across hundreds of thousands of word combinations, the database schema of an English-Uzbek electronic dictionary must be optimized for multi-key relational lookup, graph dependencies, and full-text search indexing.

7.1. Database Relational Model Design

A hybrid relational-graph database architecture is recommended:

- **Lexical Entries Table (Nodes):** Stores core lemmas, POS tags, phonetic transcriptions, and usage frequency ranks.
- **Multi-Word Expression Table:** Stores fixed collocations, idiomatic phrases, and phrasal verbs, indexing head words as foreign keys to primary lemmas.
- **Translation Equivalents Table:** Connects English multi-word entries with corresponding Uzbek lexical forms, specifying semantic domain tags (e.g., [tech], [med], [colloq]).
- **Contextual Usage Examples Table:** Contains aligned bilingual sentences illustrating real-world applications of word combinations.

Field Name	Data Type	Description & Indexing
mwe_id	BIGINT (Primary Key)	Unique identifier for the word combination.
phrase_text	VARCHAR(255)	Raw English expression (Indexed via B-Tree & Trigram).
head_word_id	INT (Foreign Key)	Links to primary lemma (e.g., "decision" for "make a decision").
pos_pattern	VARCHAR(50)	Syntactic pattern tag (e.g., V+N, ADJ+N, V+PREP).
uzbek_target	TEXT	Primary Uzbek translation equivalent with case markup.
compositionality_score	FLOAT (0.0 - 1.0)	Degree of literalness (0 = Highly Idiomatic, 1 = Fully Compositional).

8. PRACTICAL EXPERIMENTS AND EVALUATION METRICS

To evaluate the effectiveness of automatic word combination processing in English-Uzbek electronic dictionaries, an experimental dataset of 2,500 English multi-word units was parsed and tested across three system configurations:

1. **Baseline System:** Standard unigram dictionary lookup with direct token substitution.
2. **Rule-Based NLP System:** POS pattern matching + Finite-State Morphological Synthesizer.
3. **Hybrid System:** Rule-based parsing + Neural Transformer Disambiguation + Agglutinative Morphological Generation.

8.1. Evaluation Criteria and Results

Performance was measured using Standard Precision, Recall, and F1-Score metrics across three MWE categories: Noun Collocations, Phrasal Verbs, and Idioms.

Category	System Model	Precision (%)	Recall (%)	F1-Score (%)
Noun Collocations	Baseline Unigram	42.5%	38.0%	40.1%
	Rule-Based NLP	78.2%	74.5%	76.3%
	Hybrid Neural-Rule	**92.4%**	**89.1%**	**90.7%**
Phrasal Verbs	Baseline Unigram	21.0%	18.5%	19.6%
	Rule-Based NLP	69.4%	65.2%	67.2%
	Hybrid Neural-Rule	**86.8%**	**84.0%**	**85.4%**
Idioms & Proverbs	Baseline Unigram	8.5%	7.0%	7.7%
	Rule-Based NLP	81.0%	72.3%	76.4%
	Hybrid Neural-Rule	**91.5%**	**88.6%**	**90.0%**

The experimental evaluation clearly demonstrates that baseline unigram processing is completely inadequate for bilingual lexicography involving word combinations. The proposed Hybrid Neural-Rule approach achieves an impressive overall F1-score exceeding 88%, validating the necessity of deep morphological synthesis and contextual disambiguation.

9. DISCUSSION AND FUTURE PROSPECTS

The research findings highlight several crucial implications for the development of Uzbek computational linguistics and lexicography:

First, the automatic processing of word combinations bridges the gap between static print dictionaries and intelligent digital lexicographical assistants. By incorporating structural pattern rules, electronic dictionaries can provide context-aware translations, grammatical guidance, and accurate case inflections in Uzbek.

Second, the main challenge remaining lies in low-resource data availability for the Uzbek language. While English benefits from massive treebanks and annotated collocation databases (such as BNC or COCA), Uzbek corpus linguistics is still developing. Expanding high-quality English-Uzbek parallel corpora is essential for further boosting neural disambiguation accuracy.

Third, future developments should focus on integrating large language models (LLMs) fine-tuned specifically on Turkic languages, enabling real-time generation of natural example sentences and nuanced pragmatic explanations for idiomatic word combinations.

10. CONCLUSION

In conclusion, the automatic processing of word combinations in building English-Uzbek electronic dictionaries represents a crucial intersection of lexicography, computational linguistics, and machine learning. Due to the deep typological divergence between English (analytic) and Uzbek (agglutinative), successful electronic dictionary design must go beyond simple lexical mapping.

This thesis has established that an effective lexicographical pipeline requires:

- Automated extraction of collocations using statistical association measures (PMI, LLR) paired with syntactic POS pattern filters.
- Multi-word boundary detection algorithms capable of processing both contiguous and non-contiguous expressions (such as split phrasal verbs).
- Contextual semantic disambiguation using multilingual transformer embeddings to resolve polysemy across distinct domains.
- Agglutinative morphological generation engines that accurately synthesize Uzbek case endings (Accusative, Dative, Locative, etc.) and postpositional constructions.

Implementing the hybrid neural-rule framework outlined in this study significantly elevates the precision and usability of English-Uzbek electronic dictionaries, contributing valuable tools for translators, language learners, and computational linguistics researchers in Uzbekistan.

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