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Contents

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EXTENDED REGULAR EXPRESSIONS IN FINITE
AUTOMATA REVISITED
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Abstract. While the past work was focused on limited set of regular expressions (RE) within extended operators like intersection, complement and subtraction (ERE), in this article we extend the definition of RE for zero-width operators like Kleene closure. For this purpose the tagged states are implemented within the space of states of the non-deterministic finite automata (NFA) as well as for modified subset construction of deterministic finite automata (DFA). The prior research is good for extended operators, however, empty words play vital role even in extended regular expression matching as well as for typical regular expressions. Thus, the tagged states and transitions are introduced as well as the local search, which was first developed for approximate back-reference matching and now is suitable for extended operators. Thus, the linear complexity isn't avoided and is obtained for the general case of the grammars of regular expressions. It's also shown that the limited set of grammar rules for regular expressions are the good idea to obtain preliminary results for further generalization using algorithmic paradigms.

Keywords: extended operators, regular expression, algorithm.

Introduction

The prior work for ERE has the results as the membership problem for intersection is closed under LOGCFL [1] and are quadratic in general to the number of states in produced NFA.

Berry and Sethi propose derivative within the extended operators [2], however, the state explosion in this case cannot be avoided.

Neven et al. [3] study the extended operators and show comparable results to the previous research.

Laurikari, Ville, [4] introduces the tagged transitions in NFA – this is the basic idea of our present approach which will be described later in this article.

Rabin-Scott [5] construction within the extended operators [6] is also presented by the algorithm with tagged transitions.

We will use here also the local search algorithm as an alternative to the tagged transitions and show that it doesn't give the quadratic explosion of complexity or space-time tradeoff [7].

The latest research was based on limited set regular expressions [8] while the Kleene star operator was missing. In this article we show the general case when zero-width operators are included within the local search in NFA or within the modified subset construction on tagged NFA.

The best known result for the complexity of extended regular expression matching is presented in [11]. We out-perform in this article this bound giving the complexity of $O(mn)$ which is linear to both factors like the size of the expression as well as the size of the input parameter.

The problem of finding the equivalence for the short regular expression along the intersection operator is presented in [12]. Thus, the equivalence of languages can be also solved efficiently by our algorithm.

Definition of Limited ERE. Our prior research was mainly focused on limited set of non-zero width operators in ERE which are as follows:

L(R1 | R2) = L(R) : w in L(R1) or w in L(R2),
L(R1 & R2) = L(R): w in L(R1) and w in L(R2),

L(R+) = L(R): w in L(R)+,
L(R1 – R2) = L(R): w in L(R1) and w not in L(R2),
L(~R) = L(R): w not in L(R).

The above definition was used in the prior works of the author [6, 7, 8] while the Kleene star operator and zero-width elements were missing which is thus the limited set of regular expressions. Of course, we can insist on the fact that they are sufficient for matching process and are good alternative as for ideas proposed by Dominik D. Freydenberger [9] of the limited sets.

However, to feel the full power of regular expressions the zero-width Kleene closure as well as the empty word is to be introduced as they are widely used in practice to represent the common sets within the pre-defined task of the operator to code the language or pattern for matching against input string.

The limited REs presented in this article, however, aren't limited to the extended operators like intersection, subtraction and complement: at least the empty words are missing. This will be discussed further.

Definition of Zero-width ERE. The zero-width ERE mainly consist of Kleene closure operator and include empty words which are to be handled correctly without loss of generality. We've already mentioned that our prior research focused on limited set of ERE.

Thus, zero-width ERE are as follows:

L(R*) = L(R): w in L(R)*,
L(R?) = L(R): w in L(R) or w is an empty word,
L(empty word) = empty word.

Thus, we extend our common set of regular expression grammars to the zero-width operator like Kleene closure. As per the prior work [6, 7, 8] it was the limited set, however, later in this article we will show how to cope with the solutions and avoid complexity and code expansion.

The star operator gives us the possibility to encode the empty words as an alternative to the either finite or infinite sets of words in language L(R).

Zero-width ERE can be found in almost all regular expression flavors to the present time and cannot be posed as the limited set as we used it for an initial evaluation of the development of the algorithms for the general case within the operators above.

Tagged NFA for Modified Subset Construction

We tag the starting state in our construction and there onwards we save it in the state, thus making the construction possible. Another alternative to this approach would be usage of local search for NFA matching, however, our proposal is for subset construction by Dana and Scott.

In this case the quadratic explosion is avoided due to the fact that the produced DFA can be stored in table-like form.

The tag is to be placed on the incoming state from NFA construction for ERE which is defined in [6]. Thus, the tag traces the operability of the finishing state and avoids errors within the nature of concatenation operator which is essential as well as for RE and as for ERE.

Tagged NFA was introduced in [4] and was used for efficient submatch addressing, in our work we use tagged NFA with free marks to track the reachability for extended operators like intersection, subtraction and re-written complement.

The modified subset construction which was first introduced for intersection operator in [10] was of limited nature for regular expressions, however, along with the latest research presented in this article, it's clear that tagged transitions as well as tagged states in NFA solve the general case problem for zero-width operators like star (*) or Kleene closure operator.

We have to note that complexity remains the same as per limited set of operators [8] in NFA construction which is discussed further in the next section.

In any case the fact that the pre-computation is linear and the produced result is also linear

gives us the better understanding of the future of ERE matching realization from the algorithmic point of view.

Local Search and Tagged NFA alternative

The scalable window approach opposite to the naive method uses flowing window event when the The better alternative for NFA would be approximate back-reference matching for ERE [7]. In this case the linear bound for complexity also holds true as we save the local search addendums in each phase of iteration. The $O(mn)$-memory complexity is also true for tagged NFA for proper matching.

As we can see the memory consumption in this case cannot be avoided while the running time complexity goes for a better side in $O(mn)$, where m is the size of the pattern and n is the size of the sought string.

For the local search it's impossible to construct the DFA via subset construction, however, it's operable for extended regular expressions on NFA and is very effective against the quadratic complexity explosion.

The local search is also linear as well as the alternative tagged NFA construction and matching as we have to go further for the whole input, however, this fact gives us the notion for on-line algorithms which operate on the timely limited set of data. Thus, the whole string for matching is to be defined for local search rather than on-line perspective of the past work [6, 7, 8].

The local search [7] used for back-reference matching can be without loss of generality also used in ERE matching – however, this is not so simple and challenging task for practical evaluation. We can note here that limited set of regular expressions is a good solution to avoid the bad practices for algorithmic design and composition.

Conclusion

We have introduced the main goals of our experimentation with extended operators and original automata to obtain better results for ERE matching. Now, it's time for realization which is algorithmic in main case within the modified subset construction for zero-width Kleene closure or tagged NFA matching, or its alternative like local search.

Thus, the tagged NFA and local search alternatives are proposed for both NFA-matching or modified subset construction without loss of generality for star operator and empty words, which together form the practically full set of regular expressions with the extended operators like intersection, complement and subtraction.

We also use the paradigm of algorithmic simplicity which is related to the realization process, thus obtaining the efficient and linear algorithm which is well-studied in short for a better evaluation. The Java project from repository can be obtained from the author by demand.

Thus, we state the new linear complexity of two factors in $O(mn)$, where m is the size of the regular expression pattern and m is the size input string to be matched. The memory consumption due to the tagged NFA and produced DFA or local search in NFA remains same.

We also obtain a good result of not-rewriting the union operator like in prior author's work using the methods developed in this work.

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КЛЮЧЕВЫЕ ИНСТРУМЕНТЫ ПРИ РАЗРАБОТКЕ ОБРАЗОВАТЕЛЬНОЙ ПЛАТФОРМЫ «UP SKILL»

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Аннотация. Данное исследование направлено на разработку уникального программного обеспечения, чтобы устранить проблему при выборе той или иной платформы для внедрения такого рода образовательных услуг. При разработке программных продуктов вы никогда не действуете по наитию — по крайней мере, если вы не планируете бизнес-самоубийство. Всегда есть пошаговый план, которому вы следуете, чтобы перейти от одного этапа к другому, следя за тем, чтобы вы не соскользнули, переходя от идеи к внедрению. Эта статья представляет собой иммерсивный обзор процесса разработки программного обеспечения. В рамках процесса обнаружения продукта все сводится к тому, чтобы соединить точки между тем, что вы намереваетесь создать, и тем, захочет ли кто-нибудь когда-нибудь, чтобы вы это использовали. К этому моменту вы должны уже достаточно знать, зачем вы создаете продукт и кто его конечные пользователи. Но вам нужна более согласованная стратегия, чтобы ускорить процесс проектирования вместе с вашей командой. Помимо платных образовательных курсов с документальным подтверждением результатов обучения существуют и возможности бесплатного интернет-образования. Образовательные программы предполагают несколько уровней подготовки, различных по длительности и качеству.

Ключевые слова: Курсы, видеоуроки, тренинги, геймификация, дистанционное обучение, куратор, программирование, образовательная платформа.

Введение

Необходимость внедрения дистанционных инструментов обучения появилась задолго до пандемии COVID-19, однако карантинные меры до максимума усилили требование нахождения технологических решений. Идея создания платформы для дистанционного обучения и повышения навыков в определенных образовательных направлениях появилась в 2020 году. Тогда базовой причиной для запуска служило наличие большого социального пробела между городским и региональным населением. Школьники крупных городов имели преимущество в доступе к современным образовательным продуктам, тогда как их сверстники вынуждены получать «стандартные пакеты». Цифровая образовательная платформа — информационное пространство, объединяющее участников процесса обучения, которое дает возможность для удаленного образования, обеспечивает доступ к методическим материалам и информации, а также позволяет осуществлять тестирование для контроля уровня знаний обучающихся [4].

В мире отсутствуют системные технологические и организационные решения, позволяющие в полной мере добиваться тех же социальных и образовательных результатов, которые дает «обычная» школа. Родители, учителя и ученики оказались не готовы к дистанционному обучению как к единственному формату образовательного процесса. Эту ситуацию надо признать и срочно активизировать исследования и разработки, чтобы выработать решения, которые хотя бы на 70–80% позволят добиваться полноценных, соответствующих школьной программе образовательных результатов [6]. Однако надо признать, что в процессе быстрого перехода на дистанционные форматы большой проблемой стал дефицит интерактивных учебных материалов, интересных заданий с обратной связью, а также опыта и инструментов коллективной работы в цифровой среде. Проблемой стало и просто недостаточное знакомство учителей с такими инструментами.

Ключевые инструменты при разработке образовательной платформы «Up skill»
Ж. Мэлс

Новое понятие «образовательная платформа» уверенно вошло в жизнь исследователей, педагогов и студентов, однако конкретное определение этой категории нами так и не было найдено. Изучая интернет-проекты, мы пришли к следующему пониманию термина «образовательная платформа» — это ограниченный, личностно ориентированный интернет-ресурс или ограниченная интерактивная сеть подобных, полностью посвященный вопросам образования и развития, непременно содержащий учебные материалы и предоставляющий их пользователям на тех или иных условиях. Помимо платных образовательных курсов с документальным подтверждением результатов обучения существуют и возможности бесплатного интернет-образования. Образовательные программы предполагают несколько уровней подготовки, различных по длительности и качеству.

Проведенный анализ позволяет сделать следующие основные выводы:

Невозможно полностью перевести образовательный процесс в дистанционный формат, сохранив ту же эффективность. В дистанционном формате отсутствует плотная среда спонтанного личного общения, в нем нельзя реализовать полноценно механизмы дисциплинирования, социального контроля и обратной связи.

Однако качественные цифровые инструменты могут позволить добиваться хороших образовательных результатов, прежде всего с точки зрения обучения конкретным дисциплинам. Они создают возможность участия в учебном процессе детей, которые не могут посещать соответствующие уроки. Они также могут создавать возможность индивидуализации учебных траекторий и автоматизации рутинных процессов преподавания.

Основная нагрузка по контролю и сопровождению обучения детей легла на родителей. Многие ресурсы и сервисы имеют высокий методический порог входа и потребовали от родителей и педагогов существенных временных издержек, в то время как должны были, наоборот, снижать рутинную нагрузку.

Недостаточным для активного распространения обучения в дистанционной форме является предложение интерактивных образовательных ресурсов, прежде всего тренажеров комплексов интерактивных заданий с обратной связью и аналитикой.

Система образования имеет доступ к огромному многообразию общепользовательских инструментов работы с документами, коммуникации, организации групповой работы, обратной связи. Однако эти инструменты очень мало используются. Вместе с тем явно не хватает комплексных решений для школы, где эти средства были бы интегрированы с общей системой организации образовательного процесса. Без этого реализация дистанционного формата обучения может породить непонимание и путаницу.

Практически отсутствуют теоретические и практические разработки возрастной специфики использования цифровых материалов (для начальной, основной и старшей школы).

В условиях использования широкого перечня платформ, ресурсов и сервисов актуальными становятся вопросы хранения и обмена персональными данными, а также безопасности обучающихся и педагогов в цифровой среде.

Во время пандемии большинство провайдеров крупных решений предоставили свободный доступ к своим сервисам, посещаемость многих платформ выросла в 5–10 раз.

Можно выделить три основные задачи, которые помогают решить цифровые онлайн платформы для обучения [1]:

1. дистанционное обучение и контроль знаний для учебного заведения;
2. автоматизация процесса повышения квалификации и обучения сотрудников компании;
3. организация обучающих курсов в разных сферах бизнеса.

Остановимся на основных плюсах:

1. обучающийся может получать информацию в удобное время независимо от места нахождения;
2. использование современных технологий и мультимедийных средств учебный материал может быть наглядным, интересным и доступным для понимания и освоения;
3. все необходимые учебные материалы доступны проходящему обучение;
4. самостоятельная работа развивает самоорганизацию, дисциплину, инициативность;
5. возможность дистанционного обучения людей с ограниченными возможностями;
6. возможно формирование курсов с использованием новейших методик обучения;
7. получение статистики на всех этапах обучения по эффективности методики и обратной связи от обучаемых по качеству преподавания и доступности материала, что дает уникальную возможность модифицировать платформу и улучшать процесс обучения [3].

Система Up Skill

Мое решение, это упрощенный набор инструментов, который позволит легко, быстро и просто запустить продажу собственных курсов. Целью данных платформ является обеспечение высокого качества образования с помощью цифровых технологий. Данные платформы являются актуальными для детей младшего школьного возраста, так как наглядность и качественная визуализация позволяют школьникам облегчить процесс запоминания информации. В функциях для этого есть все необходимое: единый центр обучения, прием оплаты, скидки и купоны, простое управление обучением и геймификация, выдача сертификатов. Теоретическая часть курса может состоять из текста, графики и видео. Здесь есть тесты с автоматической проверкой и опросы с открытыми вопросами.

Система «Up skill» - то самое решение, вызванное закрыть данный пробел и дать детям равные академические возможности. Разработка онлайновых образовательных платформ достаточно инновационная и интересная задача. Не всегда создание подобной платформы возможно на базе стандартных решений, хотя в интернет сейчас есть много предложений. Первое, что накладывает ограничение на использование стороннего сервиса для создания вашей образовательной системе — защита информации от доступа сторонних лиц.

Популярность электронных образовательных платформ с интерактивными возможностями обучения растет. Переход на удаленное обучение требует внедрения в процесс современных методов обучения с использованием не только компьютеров, но и другой современной техники. Все платформы объединяют задачи, которые они позволяют решать, разница лишь в интерфейсе самой платформы, тарифных планах, информационном наполнении и выборе методик преподавания [2].

Основная особенность платформы — она ориентирована на обучение программистов. Однако создавать можно любые программы. Программное обеспечение позволяет собрать в системе определенную базу знаний, структурировать ее и проводить полноценное дистанционное обучение онлайн. Темы уроков могут быть самыми разнообразными, включать в себя теоретическую и практическую части, тексты и видео, тестирование и сертификацию, игровые элементы и домашние задания, контроль прогресса и статистику [2]. Возможность использовать разные типы обучающих материалов (курсы, вебинары, тренинги, марафоны), а также загружать разные виды контента (тексты, видео, изображения, файлы, презентации).

Безусловно, коммерческие платформы оказываются более привлекательными в этой сфере, поскольку такие проекты требуют финансовых затрат и команды грамотных специалистов как в области сайтостроения, рекламы, так и в педагогике (дидактике). Сокращение временных затрат на обучение и повышение качества образования являются ориентирами современности. Именно такими маркерами можно обозначить процесс интенсификации обучения. Интенсификация в образовании в широком смысле — процесс, целью которого является повышение эффективности обучения, усвоение большего объема

информации за меньший или прежний интервал времени.

Дистанционное обучение предполагает изучение материала обучающимся в большей мере самостоятельно, по индивидуальному плану, в соответствии с личными возможностями и желанием студента. Обучение такого типа включает взаимодействие преподавателя и студента, в основном, посредством Интернета. В результате активного использования сети Интернет как в дистанционном, так и в онлайн-образовании у большинства пользователей и образовательных организаций, презентующих образовательные курсы и программы, происходит слияние этих двух форм обучения. Отличие же онлайн-образования в том, что процесс обучения в большей степени предполагает интерактивное информационно-образовательное пространство при активном участии педагога как организатора и модератора онлайн-взаимодействия, процесс максимально похож на традиционное обучение, но аудиторные занятия проходят в виртуальной среде.

Сегодня в мире существует большое разнообразие инструментов, которые могут быть использованы в учебной деятельности. В этом разделе мы постарались выявить и систематизировать те виды цифровых сервисов и инструментов, которые:

1. имеют историю использования в системе образования;
2. распространены в русскоязычном сегменте Интернета;
3. вокруг которых уже сложились сетевые сообщества;
4. имеют сформированные базы знаний, где каждый желающий использовать сервис сможет оперативно получить дополнительную информацию;
5. имеют низкий порог входа и подходят для педагогов, не имеющих сильных ИТ-компетенций.

Мы систематизировали сервисы по нескольким категориям относительно образовательных задач, которые можно решать с их помощью. В описании приводятся либо прямые ссылки на сетевые сообщества и ме- тодические материалы, в которых педагог может найти лучшие практики, либо, если таких сообществ много, более общие описания сообществ, по- зволяющие найти интересующие материалы. Первые пять категорий охватывают универсальные сервисы, которые могут быть полезны педагогам независимо от их предмета, остальные — специализированы и востребованы при организации дистанционной ра- боты по определенным школьным предметам.

Ключевые инструменты системы Up Skill

Ключевым инструментам системы Up Skill относятся:

1. Курсы: каждый курс - это предмет, включающий в себя набор различных инструментов для успешной подготовки.
2. Видеоуроки: каждая программа имеет несколько модулей, в каждом модуле имеется ряд видеоуроков на различные темы.
3. Тесты: в конце обучения тесты по всем обучающим Курсам.
4. Тренировки - это мини-тесты для поддержания формы и подготовки к основным тестам. Здесь применяется техника фитнеса - развитие качеств и рост мышц возникает путем регулярных тренировок. Также и с образовательными навыками.
5. Store - вы можете приобрести понравившиеся Вам курс и начать обучаться.

Геймификация - важный компонент при разработке современных образовательных программ, особенно ориентированные для детей и подростков. К сожалению, сейчас завоевать внимание ребенка гораздо сложнее ввиду огромного контента вокруг него. В списке приоритетов и интересов далеко не каждый ребенок поставит программирование выше компьютерных игр, Marvel'овских сюжетов и прочих красочных видеорешений. Для того, чтобы хоть как-то конкурировать с вышеописанным контентом, необходимо внедрять игровые процессы в образовательные решения.

Куратор анализирует результаты ребенка, корректирует программу подготовки и выстраивает эффективные пути для получения прогресса. Также должны присутствовать

видеоконференции в онлайн формате, где в режиме реального времени объясняют и разбирают различные тесты. Так как образование, это процесс двусторонний, все участники данного процесса прикладывают максимум усилий для достижения результата.

Заключение

Остальные возможности платформ не столь важны, но мы также будем обращать на них внимание, например: на удобство интерфейса, наличие бесплатного тестового периода, стоимость работы техподдержки, сложность освоения, интеграцию с сервисами, возможность кастомизации и брендирования и пр.

Применяемые в массовых и приватных онлайн-курсах образовательные технологии должны обеспечивать возможность достижения результатов обучения независимо от места нахождения студентов. В силу малого количества слушателей в приватных курсах возможна организация синхронных мероприятий: вебинаров, онлайн-консультации, презентаций проектов и т.д. Применяемые в массовых онлайн-курсах методы и средства обучения должны допускать рост количества слушателей без существенного роста трудоемкости сопровождения и без прямого участия в работе со студентами авторов программы. Таким образом, в массовых курсах не должны применяться синхронные образовательные технологии. При планировании содержания следует четко разделять обязательные и дополнительные элементы онлайн-курса, поскольку это способствует сокращению нагрузки на слушателя при сохранении планируемых результатов обучения. Курсы, реализующиеся полностью онлайн, должны содержать все материалы, необходимые для выполнения всех форм контроля и достижения всех запланированных результатов обучения. Студенты могут участвовать в процессе формирования нового контента курса. Философия заключается в построении треугольника между родителем, ребенком и компанией, во главе которого безусловно стоит ребенок.

Таким образом, образовательные платформы являются удачным источником информации для педагогов, задача которых заключается в подборе и внедрении материала в учебный процесс. Необходимо использовать эти инструменты для разнообразия процесса обучения, развития интереса школьников, повышения мотивации к обучению и т.д. Активное использование образовательных платформ, сетевых ресурсов позволит создать виртуальную образовательную среду общеобразовательной школы

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«UP SKILL» БІЛІМ БЕРУ ПЛАТФОРМАСЫ ДАМЫТУДЫҢ НЕГІЗГІ ҚҰРАЛДАРЫ

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Аңдатпа. Бұл зерттеу білім беру қызметтерінің осы түрін жүзеге асыру үшін сол немесе басқа платформаны таңдау кезінде проблеманы жою үшін бірегей бағдарламалық қамтамасыз етуді әзірлеуге бағытталған. Бағдарламалық жасақтама өнімдерін әзірлеу кезінде сіз ешқашан еріксіз әрекет етесіз - кем дегенде. Әрқашан бір кезеңнен келесі кезеңге өту үшін орындалатын қадамдық жоспар бар, идеядан іске асыруға көшкен кезде сырғып кетпейтініңізге көз жеткізіңіз. Бұл мақала бағдарламалық жасақтаманы әзірлеу процесінің толық шолуы болып табылады. Өнімді табу процесінің бір бөлігі ретінде бұл сіз жасағыңыз келетін нәрсе мен біреу оны пайдаланғыңыз келетін-келмейтіні арасындағы нүктелерді байланыстыру туралы. Осы сәтте сіз өнімді не үшін жасап жатқаныңызды және оның соңғы пайдаланушылары кім екенін жеткілікті білуіңіз керек. Бірақ сіздің командаңызбен дизайн процесін жылдамдату үшін сізге үйлесімді стратегия қажет. Оқыту нәтижелерінің құжаттық дәлелі бар ақылы білім беру курстарынан басқа, тегін онлайн білім алу мүмкіндігі де бар. Білім беру бағдарламалары ұзақтығы мен сапасы бойынша әртүрлі оқытудың бірнеше деңгейін қамтиды.

Түйін сөздер: Курстар, бейне оқулықтар, тренингтер, геймификация, қашықтықтан оқыту, куратор, бағдарламалау, білім беру платформасы.

KEY TOOLS IN THE DEVELOPMENT OF EDUCATIONAL PLATFORMS "UP SKILLS"

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Abstract. This research is aimed at developing unique software to eliminate the problem when choosing one or another platform for the implementation of this kind of educational services. When developing software products, you never act on a whim - at least not unless you are planning business suicide. There is always a step-by-step plan that you follow to move from one stage to the next, making sure you don't slip as you move from idea to implementation. This article is an immersive overview of the software development process. As part of the product discovery process, it's all about connecting the dots between what you intend to build and whether or not someone will ever want you to use it. At this point, you should already know enough why you are creating a product and who its end users are. But you need a more coherent strategy to speed up the design process with your team. In addition to paid educational courses with documentary evidence of learning outcomes, there are also opportunities for free online education. Educational programs involve several levels of training, different in duration and quality.

Keywords: Courses, video tutorials, trainings, gamification, distance learning, curator, programming, educational platform.

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THE NEW APPROACHES TO FACE RECOGNITION METHODS

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Abstract. Nowadays it is major to use recognition systems in each aspects of human life to automate and to speed up some processes where we need quickly find something. This article examines the main trend of technologies and algorithms of recognition systems which can use now and can give good results. The disadvantages and advantages of three common schemes for the implementation of the face recognition system are provided. The coefficients such as FAR and FRR are calculated for the main methods of biometric identification. The dynamics of the development of the use of face recognition systems is described. It is known that knowledge of trends and dynamics of the development are very important and first main step in research process. Of course, without knowing what is required and changing in this area, it is difficult to judge what exactly is in demand right now. It will also be impossible without knowledge to predict or make assumptions about what will be in demand in the future.

Keywords: face recognition, FAR, FRR, 2D face recognition, 3D face recognition.

Введение

Nowadays face recognition is one of the most promising methods of biometric contactless identification of a person by face. The first face recognition systems were implemented as programs installed on a computer. Nowadays, facial recognition technology is most often used in video surveillance systems, access control, on a variety of mobile and cloud platforms. Massachusetts Institute of Technology Journal - MIT Technology Review ranked facial recognition technology as one of the 10 Breakthrough Technologies of 2017 [1]. There is no difficulty in illustrating the fantastic efficiency. In China, there are more than a billion people in the database of the unified tracking and recognition system. The system uses 170 million cameras in real time. It took a British BBC journalist 7 minutes to check how long it would take to be detained if he moved around the capital of China, Beijing, while in the base of dangerous persons.

Bloomberg estimates the global face recognition market will grow from $ 4.05 billion in 2017 to $ 7.76 billion by 2022.
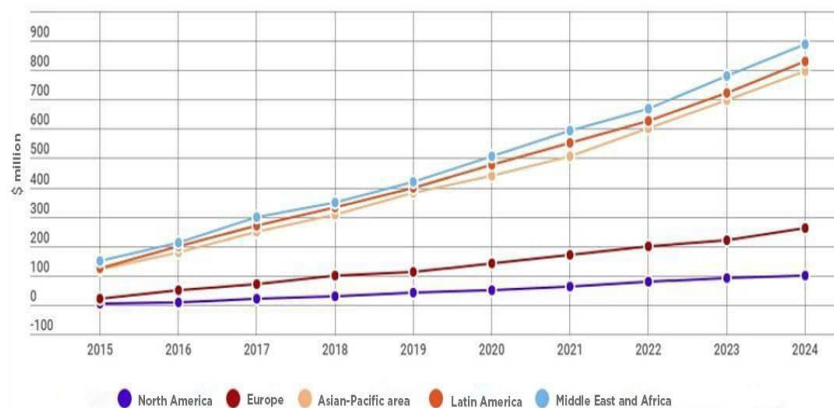

Figure - 1. The amount of money earned from facial recognition technologies according to

The new approaches to face recognition methods
P. Komada, Ye. Amirgaliyev, A. Sadykova
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Description of the work of the face recognition system

By the way, a face recognition system can be described as a process of matching faces that have fallen into the camera lens with a database of previously saved and identified images of reference faces. According to the structural implementation of the face recognition system, three common schemes can be distinguished [2].

The first one is Analysis of the video stream on the server. The most common implementation scheme - an IP camera transmits a video stream to the server, on the server, specialized software analyzes the video stream and compares the images of faces obtained from the video stream with a database of reference faces.

Figure - 2. Analysis of the video stream on the server

The disadvantages of such a scheme will be high network load, high server cost, even the most powerful server can be connected to a limited number of IP cameras, i.e. the larger the system, the more servers.

The advantage is the ability to use an existing video surveillance system.

The second one is analysis of the video stream on the IP camera. In this case, the image analysis will be performed on the camera itself, and the processed metadata will be transmitted to the server.

Figure - 3. Analysis of the video stream on the IP camera

Disadvantages - special cameras are needed, the choice of which is extremely small at the moment, the cost of cameras is higher than usual. Also, in systems of different manufacturers, the issue of storage and size of the database of recognized faces of standards will be solved in different ways, as well as issues of interaction between software on the camera and software on the server.

Advantages - connection of an almost unlimited number of cameras to one server.

The third one is analysis of the video stream on the access control device. Unlike the first two schemes where IP cameras are used, in this case the camera is built into an access control device, which, in addition to face recognition, which naturally occurs on the device, performs access control functions, usually through a turnstile or an electric lock installed on the door. The database of reference faces is stored on the device, and usually no longer in the form of photographs.

Figure - 4. Analysis of the video stream on the access control device

Disadvantages - as a rule, all such devices are produced for indoor use.

15

Advantages - low cost of systems in comparison with video surveillance systems used for face recognition.

In any case, the success of a face recognition project depends on three important factors:
• Recognition algorithm
• Databases of recognized faces (patterns)
• Algorithm speed

Face recognition technology

Typically, the system consists of a CCTV camera and software that performs image analysis. Facial recognition software is based on image processing and computation of complex mathematical algorithms that require a more powerful server than is usually required for video surveillance systems.

We will be primarily interested in the quality indicators of the software. Secondly, what server power will be needed to analyze the image and process the database with images, and in the third, we will consider the issue of the applicability of IP cameras for the purposes of face recognition. Special attention should be paid to the so-called "stand alone" devices, which perform image processing directly on the device itself and not on the server; also on such devices there can be a database of reference faces in memory [3].

2D face recognition. 2D (two-dimensional) face recognition technology is based on flat two-dimensional images. Face recognition algorithms use: anthropometric parameters of a face, graphs - face models or elastic 2D-models of faces, as well as images with faces represented by a certain set of physical or mathematical features. We will consider the popularity rating of face recognition algorithms below.

2D image recognition is one of the most popular technologies at the moment. Since the main databases of identified persons accumulated in the world are precisely two-dimensional. And the main equipment already installed around the world is also 2D - as of 2016 - 350 million CCTV cameras. That is why the main demand is for 2D face recognition systems.

And demand, as you know, stimulates supply, forcing developers to maximize efforts to improve the 2D technology. These efforts sometimes bring unexpectedly interesting results, for example in the form of creating a 3D face model from a 2D image. Researchers from the Universities of Nottingham and Kingston have presented a 3D facial reconstruction project based on one single image. The neural network, through which many volumetric 3D models of people and ordinary portraits were passed, recreates the volumetric faces of people based on just one two-dimensional face image.

Advantages. The huge advantage of 2D face recognition is the availability of ready-made databases of face standards, and ready-made infrastructure. The maximum demand will fall on this segment, and the demand will stimulate developers to improve technologies.

Disadvantages. Higher FAR and FRR error rates compared to 3D face recognition.

3D face recognition. 3D recognition is usually performed based on reconstructed 3D images. 3D face recognition technology has higher quality characteristics. Although, of course, it is not ideal either [4].

There are several different 3D scanning technologies. These can be laser scanners with an estimate of the distance from the scanner to the elements of the object's surface, special scanners with structured illumination of the object's surface and mathematical processing of the bends of the stripes, or it can be scanners that process synchronous stereopairs of face images using the photogrammetric method.

One of the most researched 3D scanners by consumers and experts is Apple's famous Face ID. The experience of using Face ID is extremely interesting and indicative, because, in fact, this is the only device with 3D face recognition technology released to the mass market, if, of course, you can consider the phone as a hundred as a device for the mass market.

Apple's 3D technology is the only one in the world that uses vertical emitting lasers (VCSELs), rumored to have spent $ 1.5 billion to $ 2 billion on Face ID. VCSEL is supplied to Apple by two companies Finisar Corp (Apple investment - $ 390 million) and Lumentum Holdings. And judging

by the fact that other 3D technologies do not show such efficiency as Face ID, face unlocking on Android smartphones will not appear soon.

Naturally, Face ID does not cope with the tasks of identifying twins, although no one expected this, but even with close relatives, failures happen. Result of comparative rates of FAR and FRR represented in the table 1.

Table – 1. Rates FAR and FRR in 2D and 3D cases

Biometric identification method	False acceptance rate (FAR)	False rejection rate (FRR)
Face recognition 2D	0.1%	2.5%
Face recognition 3D	0.0005%	0.1%

Advantages of 3D. Greater accuracy and fewer errors are still unattainable for 2D face recognition systems.

Disadvantages of 3D. Easy enough to fake for professionals. Even Face ID, despite all the coolness, was hacked by the Vietnamese company Bkav immediately after it went on sale. The mask was created using a 3D printer. The cost of creating a mask is only $ 150. Making a mask is difficult enough for an average person, and your mom is unlikely to be able to do it, but for professionals it is like two fingers on the asphalt.

Do not use 3D facial recognition to protect against unauthorized access to laptops, smartphones, rooms with a special level of secrecy, all of them can be easily hacked by professionals.

• 3D recognition requires special cameras for scanning, which are several times more expensive than conventional CCTV cameras that are used in 2D recognition.

• Lack of ready-made databases of identified faces, compared to 2D recognition

• Twin recognition remains challenging for face recognition algorithms. On average, twins are born per 1000 newborns worldwide, and this number varies greatly depending on the geographic region.

The quality of the software

There are several important metrics for evaluating software quality. The most important of them are FRR and FAR [5].

• False Reject Rate, FRR - the probability that the system does not identify the registered user or does not confirm his authenticity. FRR is calculated as follows:

Let N_t be the number of reference images in the database. FR - the number of false non-recognitions (False Reject - Sadykova, not recognized as Sadykova),

$$FRR = \frac{FR}{N_t} \times 100\% \tag{1}$$

• False Acceptance Rate, FAR - the probability that the face recognition system mistakenly identifies an unregistered user or confirms his authenticity. FAR is calculated as follows:

Let N_t be the number of reference images in the database. FA - the number of false recognitions (False Acceptation - Sadykova is recognized as Amirgaliyev),

$$FAR = \frac{FA}{N_t} \times 100\% \tag{2}$$

The first and most important thing you need to know about these two indicators is that they are not absolute, but relative, i.e. they may vary depending on the settings of the face recognition algorithm. The second is that these indicators are interrelated - the lower the FAR, the higher the FRR. The approximate values of FRR and FAR for face recognition systems and their relationship are presented in the table 2 and table 3.

Table – 2. The approximate values of FRR and FAR for face recognition systems

FAR	FFR
0.1%	2.5%
0.01%	7%
0.001%	10%

Table – 3. Comparison of FAR and FRR of different biometric identification methods

Biometric identification method	False acceptance rate (FAR)	False rejection rate (FRR)
Face recognition 2D	0.1%	2.5%
Face recognition 3D	0.0005%	0.1%
Fingerprint	0.001%	0.6%
Iris	0.00001%	0.016%
Retina	0.0001%	0.4%
Vein drawing	0.0008%	0.01%

Developers of face recognition algorithms

A recognition algorithm is usually not a ready-made software product, but a software algorithm that has yet to be packaged into a software product and equipment.

There are a lot of manufacturers of recognition algorithms in the world, since there are independent organizations that test the effectiveness of algorithms. The most famous: NIST - US National Institute of Technology Standards and MegaFace - University of Washington, Labeled Faces in the Wild, there are others. Competition results are constantly updated. Any company can update its result at any time by re-passing the test. Not long ago NtechLab declared itself as the winner, but today they are only in 4th place. NIST testing with results 2018 year will published here. Since NIST conducts testing of algorithms, it takes place on a closed database of persons, which excludes the preparation of the developer for testing [6].

First place algorithm is megvii-000 from Megvii, China [7]. This company Megvii with its main products Face ++. According to estimates, the company's turnover was about $ 100 million.

Second place algorithm is visionlabs-003, 7th place - visionlabs-002, VisionLabs, Russia [8].

Third place algorithm is morpho-002, 17th place - morpho-000. OT-Morpho, France [9]. It is the first heavyweight in the ranking with a turnover of almost 3 billion euros in 2017. Joint venture between Oberthur Technologies (OT) and Safran Identity & Security (Morpho).

In fact, there are many more manufacturers of recognition algorithms, you can find many missing here in the MegaFace rating. But even if you make a single list, it will still not be complete. Almost all IT industry giants are developing their own face recognition algorithms - Facebook, Google (considers its recognition system the most accurate), Baidu, Microsoft, Yandex (tests driver authorization by face and voice), Vkontakte, Toshiba and many others. There are even open source face recognition systems. From all this diversity, several simple conclusions can be drawn: Competition in this market will intensify, its consequence has already become a multiple reduction in prices. For example, Macroscop lowered its prices for the recognition module by 18 times, which they happily report on their own website, as if sending a "big hello" to all their customers who were lucky enough to buy the recognition module before 2017.

It is obvious that prices will continue to decline. The quality indicators of recognition algorithms are constantly growing, and in many cases they differ insignificantly from each other,

the price is significantly different, as you can see below, the performance differs even more significantly, naturally such a parameter as performance should be tested on a database of maximum volume. It is also easy to see that there are practically no manufacturers of equipment for video surveillance systems in the ratings, and without video cameras and storage devices, this whole story with algorithms is only playing on a computer. But the fact that they do not exist does not mean that they do not see this market and do not understand its importance. Here's facial recognition from Panasonic, NEC, Amazon and many more. In general, this market will soon become very hot. In addition to software solutions (this is when the recognition takes place directly on the server), there are also Stand Alone solutions - this is when the recognition takes place on the reader.

Fields of application of face recognition systems

The specificity of the application of face recognition technology differs in different criticality to errors, depending on the field of application [10].

List of main areas of application for face recognition:
• Access control systems
• Face recognition in transport
• Time tracking
• Face recognition in a crowd
• Age determination
• Gender determination
• Counting unique visitors
• Authorization
• Payment systems
• Enterprise management systems

Face recognition technology is just entering the market, and no one can imagine the number of applications now, here are just a few of them:

• China has installed cameras with facial recognition to ensure that each person receives exactly the same amount of toilet paper.

• Airbnb in China will implement registration using a facial recognition system.

• Cameras installed in a school in Hangzhou not only recognize faces, but recognize and record six types of student activity - reading, writing, listening, sleeping, as well as answering the teacher and raising a hand if the child wants to ask something.

• Tele2 and Sberbank launched sales of SIM cards through terminals with face recognition

• Russian cinema chains have launched age and gender detection systems
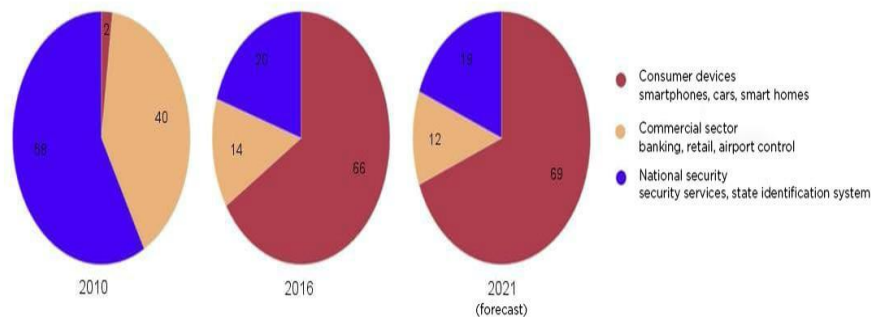

Figure - 5. Industries in which the greatest opportunities for the implementation of face recognition systems are concentrated

Conclusion

It is known that the topic of recognition system is relevant and the industries in which the greatest opportunities for the implementation of face recognition systems are concentrated every year only grows and develops. This article provides basic concepts and identifies development trends. The advantages and disadvantages of these technologies, namely, the recognition

technologies for today, are given. The paper also shows the calculations of the FRR and FAR, respectively. Revealed the relationship between the two coefficients. These tables and figures in the main part of the article inform and illustrate the dynamics of the development of recognition systems, in particular face recognition. Judging by the data presented in the article, it is safe to say that the systems and technologies in this industry are advanced and will be in demand. After all, such giant companies as Facebook, Google and Apple annually invest more and more in research on this topic.

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Бетті тану әдістеріне арналған жаңа тәсілдер
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Аңдатпа. Қазіргі уақытта қандай да бір нәрсені жылдам анықтау қажет болатын кейбір процестерді автоматтандыру және жеделдету үшін адам өмірінің барлық аспектілерінде тану жүйелерін пайдалану маңызды. Бұл мақалада қазіргі уақытта қолдануға болатын және жақсы нәтиже бере алатын тану жүйелерінің технологиялары мен алгоритмдерінің негізгі бағыттары қарастырылады. Бетті тану жүйесін енгізудің үш жалпы схемасының кемшіліктері мен артықшылықтары келтірілген. Негізгі биометриялық сәйкестендіру әдістері үшін FAR және FRR сияқты факторлар есептеледі. Бетті тану жүйелерін қолданудың даму динамикасы сипатталған. Даму тенденциялары мен динамикасын білу өте маңызды және зерттеу үдерісіндегі алғашқы негізгі қадам екені белгілі. Әрине, бұл салада не талап етілетінін және өзгермейтінін білмейінше, дәл қазір сұраныстың нақты қандай екенін анықтау қиын. Сондай-ақ болашақта сұранысқа ие болатын нәрсені болжау немесе жорамал жасау білім және жаңа ақпаратсыз мүмкін емес.
Түйін сөздер: бетті тану, FAR, FRR, 2D бетті тану, 3D бетті тану.

Новые подходы к методам распознавания лиц
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The new approaches to face recognition methods
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Абстракт. В настоящее время важно использовать системы распознавания во всех аспектах человеческой жизни, чтобы автоматизировать и ускорить некоторые процессы, где нам нужно что-то быстро детектировать. В данной статье рассматриваются основные направления технологий и алгоритмов систем распознавания, которые можно использовать уже сейчас и которые могут дать хорошие результаты. Приводятся недостатки и преимущества трех распространенных схем реализации системы распознавания лиц. Такие коэффициенты, как FAR и FRR, рассчитываются для основных методов биометрической идентификации. Описана динамика развития использования систем распознавания лиц. Известно, что знание тенденций и динамики развития является очень важным и первым основным шагом в исследовательском процессе. Конечно, не зная, что требуется и меняется в этой сфере, сложно судить, что именно сейчас востребовано. Также будет невозможно без знаний предсказать или сделать предположения о том, что будет востребовано в будущем.

Ключевые слова: распознавание лиц, FAR, FRR, 2D распознавание лиц, 3D распознавание лиц.

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MECHANISM OF METHODS USED WHEN WORKING WITH DOCUMENTS AND PROCESSING DOCUMENTS USING ARTIFICIAL INTELLIGENCE
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Abstract. Automation of the processes of analysis, processing and transmission of information in the development of information systems reduces the complexity of implementation, time and material costs, frees up the resources of developers to solve more complex and creative tasks. The transition of document management now to electronic document management technologies not only dramatically accelerates the speed of business processes of companies, but also provides cost savings when abandoning paper media, to minimize most operations when processing electronic documents, the use of artificial intelligence technologies is considered effective. In the article I will consider the possibilities of artificial intelligence technologies used in the process of enterprises, in converting documents into electronic and in the exchange of electronic documents.

Depending on the structure of the text, the review of the applied methods of artificial intelligence, neural networks and the analysis of their work processes is carried out. Depending on the structure of the document, neural networks are used. Various recognition methods can be used for image recognition according to the characteristics of the recognized characters. The article describes the mechanism of image recognition, the document processing process, the operation of NLP algorithms. Processing documents of a professional organization with the help of artificial intelligence used in it improves the quality of the document flow of the enterprise, leads to time savings and cost reduction.

Key words: artificial intelligence, electronic document, neural network, recursive networks, NLP.

Introduction

Artificial intelligence should be able to do something that can be used in everyday or professional human activities, such as reading from an image or collection of images, inscriptions, and image information. It is difficult to analyze texts using artificial intelligence: the multi-meaningfulness of one word and the use of different languages make it difficult to process them automatically. If we take the phrase "they must be in the warehouse", you will not be able to understand with 100% accuracy, that is, we are talking about people in the warehouse or things that are stored in the warehouse? A broader context is needed to address this.

Artificial intelligence, which processes documents, turns scanned paper into structured information in the form of an electronic document. Let's focus on two different components: computer vision and word processing. Computer vision allows you to edit PDF, scanned images, and images in text format. However, first you need to do a structural analysis of documents: find where text blocks, images, and tables are located, and then find out how they interact with each other. At the same time, images or documents can come in different situations because they are an existing substance. For example, there may be streaks left after the printer, photos taken of the wrong quality, documents with coffee stains. All this needs to be resolved in some way in order to obtain the correct information.

Main part

Image recognition Working Mechanism:
- Images are extracted and processed.
- Documents are aligned and adjusted.
- Then the surface structure is analyzed and block types are determined.
- Once blocks are defined, rows and columns are defined.

- You can divide lines by words into words by symbols
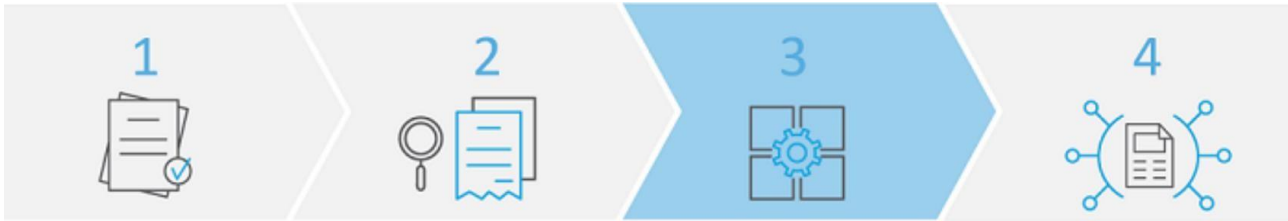
1. Getting and editing images;
2. Analysis of facial structure;
3. Text recognition;
4. Synthesis and storage of recognized fragments of documents in the required format;

When recognizing documents using artificial intelligence, as I mentioned earlier, it is necessary to recognize documents by dividing them into pages, pages into blocks, blocks into rows and columns, rows and columns into words, words into symbols. After that, we collect the recognized characters by combining words into words, words into lines, lines into blocks, blocks into pages, and pages into documents. In the recognition of documents plays an important role in its structure.

Document types:
- Multi-texture: business cards, checks, invoices
- Less structured: articles, magazines, etc.

If the document type is fixed, it differs slightly from the multi-structured document type and from each other in terms of document structure, you can use methods that learn how to directly extract the necessary attributes from a text document using text and graphic designations. For example, you can extract elements from network textures using repetitive neural networks. Invoices are documents containing the names of goods and a description of the methods of payment for these goods.

Figure – 1. Invoices and receipts. Multi-structured documents

For example: if we receive checks, you can issue a check number, date, valid account through neural networks. Convolutional neural networks are good for single attributes that have a certain position, and recurrent neural networks are good for repeating elements. The convolutional layer

is the basic unit of a neural network. And when recognizing a convolutional layer, the number of parameters is relatively small. On (figure 2) shows the transformation of a convolutional neural layer in several output channels. For the original image (Figure 2), it has a size of 28x28 pixels, which means 2352 input neurons.
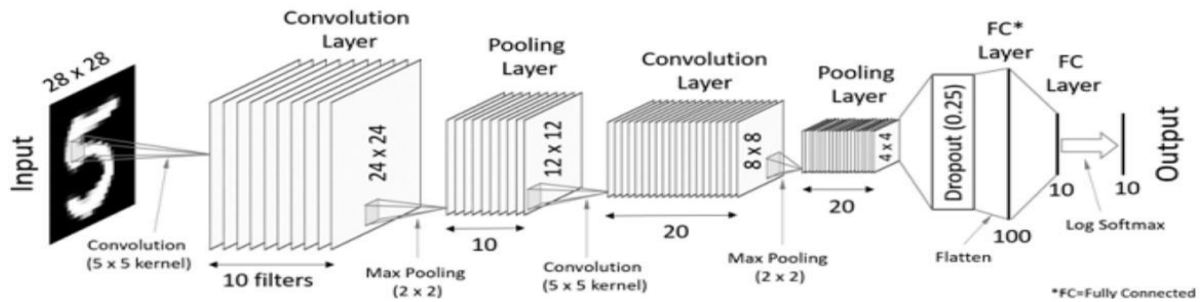

Figure – 2. Transformation of the convolutional neural layer in several output channels

If the document is less structured, NLP machine learning is used in text processing. This can be difficult due to the fact that multi-valued words are often used here. For example: the word address can mean the address of the company, or it can mean the obligation of the client to solve some problems.

Vendor's address is …

Vendor will have to address the problem …

From uploading a document to extracting the required fields, processing will be conceptually as follows:
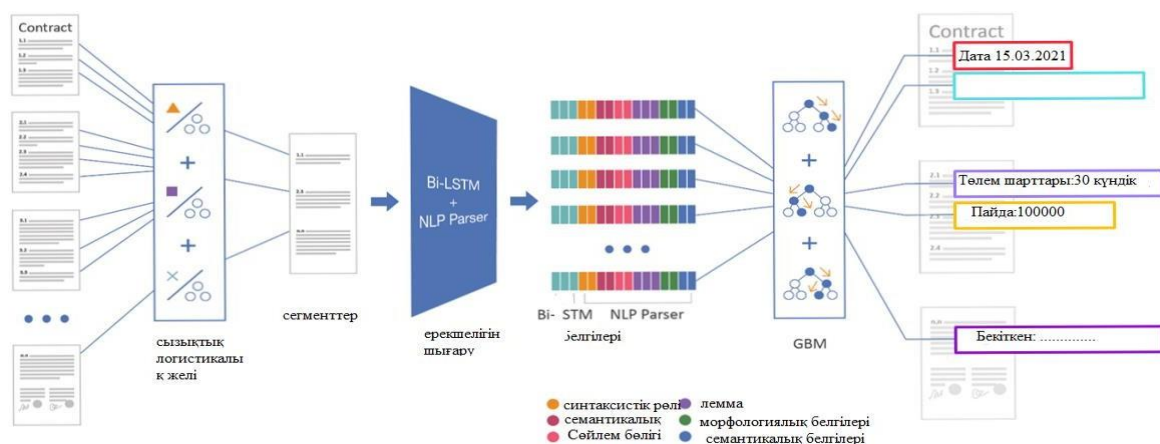

Figure – 3. Document processing process

When segmenting documents, that is, narrowing the information search area, we process not all 50 pages, but only 5 segments by paragraph, which may contain the date we need. This greatly simplifies the operation of algorithms, as well as distinguishes the desired date from other information. In Figure 2, all the steps to the right of segmentation describe the operation of NLP algorithms - a detailed study, reading, and understanding of the text. These processes take 10-20 times longer than classification and segmentation, so it is not correct to use them in a multi-page document, they are easier to use in small texts. NLP parser + Bi - LSTM-with their help, exceptions are obtained from each sentence in the text.

The engine reads the text in detail and deduces many generalizations from it. He understands not only what is specifically formulated in this sentence, but also the meaning - what it really means. The next stage is considered to be the output of symbols by text. There are also top-level labels. The classic and simplest machine learning method, GBM, is used to produce top-level tokens. As you can see in Figure 2, an ensemble of trees that show the overall result on the resulting fields. GBM-it is important to have a sufficient number of documents in order to learn quickly and effectively extract information.

If their number is small, then the quality of obtaining information may decrease. This is due to the fact that the core of cases becomes smaller and, accordingly, it becomes worse to distinguish machine - isolated cases from more common cases.

Many people rent a lot of land for construction and offices. And such documents need to be processed automatically: they need to be extracted from them by the start and end dates, so that they can track whether payments are missed later, when the lease expires, where the contract is automatically renewed, and how much it all costs.

In such a contract, information is generated using NLP, and tabular data is generated using FlexiLayout, and all other fields are generated using segmentation. The advantage of NLP technologies is that it is another mechanism that can handle more types of fields and documents.
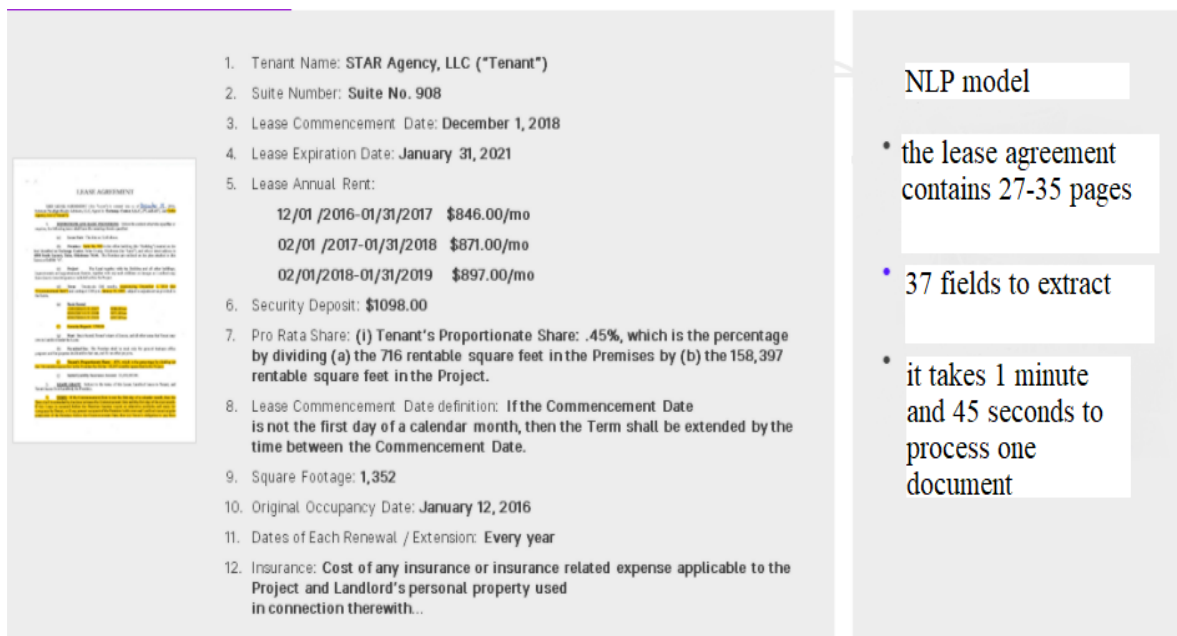

Figure – 4. «Contract», NLP model efficiency

Conclusion

Using these examples, you can see how artificial intelligence technology– which helps to save time-can be used. In English, this scheme is called "win-win": robots perform repetitive tasks, saving time for employees to engage in more intelligent and interesting projects. Companies that work with artificial intelligence, rather than everyday specialists, create interaction with customers more efficiently, avoid errors when processing certain documents, and increase profitability faster.

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Жасанды интеллект көмегі арқылы құжаттармен жұмыс жасау жәнеқұжатты өндеу кезінде қолданылатын әдістер механизмі

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Аңдатпа. Ақпараттық жүйелерді әзірлеу кезінде ақпаратты талдау, өндеу және беру процестерін автоматтандыру іске асырудың күрделілігін, уақыт пен материалдық шығындарды азайтады, әзірлеушілердің ресурстарын неғұрлым күрделі және шығармашылық міндеттерді шешуге босатады. Құжат айналымынын қазір электронды құжат айналым технологияларға көшу компаниялардың бизнес-процестерінің жылдамдығын түбегейлі жеделдетіп қана қоймай, қағаз тасымалдаушылардан бас тартқан кезде қаражатты үнемдеуді қамтамасыз етеді,электрондық құжаттарды өндеудегі көп операцияларды барынша азайту үшін жасанды интеллект технологияларын қолдану тиімді болып саналады. Мақалада кәсіпорындардың жұмыс процес кезінде қолданылатын құжаттарын электронды түрге өзгертуде және электронды құжат алмасуда қолданылатын жасанды интеллект технологияларының мүмкіндіктерін қарастыратын боламын.

Мәтін құрылымына қарай қолданылатын жасанды интеллект әдістерін, нейрондық желілерін қарастыру және олардың жұмыс процестеріне талдау жасалынады. Құжат құрылымына қарай бөлініп, құрылымдары бойынша нейрондық желілер қолданылады. Суреттерді тану үшін таңбалардың сипаттамаларына сәйкес танудың әртүрлі әдістерін қолдануға болады. Мақалада суреттерді тану жұмыс механизмі, құжаттарды өндеу процессі, NLP алгоритмдерінің жұмысын сипаттайды. Кәсіптік ұйым құжаттарын өндеу, онда қолданылатын жасанды интеллект көмегімен кәсіпорын құжат айналым сапасын көтеріп, уақыт үнемділігі мен шығындарды азайтуға алып келеді.

Кілттік сөздер: жасанды интеллект, электронды құжат, нейрондық желі, рекурренттік желілер, NLP.

Механизм методов, используемых при работе с документами и обработке документов с помощью искусственного интеллекта

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Аннотация. Автоматизация процессов анализа, обработки и передачи информации при разработке информационных систем снижает сложность реализации, временные и материальные затраты, освобождает ресурсы разработчиков для решения более сложных и творческих задач. Переход документооборота сейчас на технологии электронного документооборота не только кардинально ускоряет скорость бизнес-процессов компаний, но и обеспечивает экономию средств при отказе от бумажных носителей, для минимизации большинства операций при обработке электронных документов эффективным считается использование технологий искусственного интеллекта. В статье я рассмотрю возможности технологий искусственного интеллекта, используемых в процессе работы предприятий, в преобразовании документов в электронные и в обмене электронными документами.

В зависимости от структуры текста проводится рассмотрение применяемых методов искусственного интеллекта, нейронных сетей и анализ их рабочих процессов. В зависимости от структуры документа используются нейронные сети. Для распознавания изображения могут использоваться различные методы распознавания в соответствии с характеристиками распознаваемых символов. В статье описывается механизм работы распознавания изображений, процесс обработки документов, работа алгоритмов NLP. Обработка документов профессиональной организации с помощью искусственного интеллекта, применяемого в ней, повышает качество документооборота предприятия, приводит к экономии времени и снижению затрат.

Ключевые слова: искусственный интеллект, электронный документ, нейронная сеть,

рекуррентные сети, NLP.

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