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O Estado da Arte do Processamento de linguagem natural em histórias de usuário

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“E tudo quanto fizerdes, fazei-o de todo o coração, como ao Senhor.”
Bíblia Sagrada Colossenses 3:23

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Resumo

A história de usuário é uma técnica da metodologia ágil que surgiu do método XP (*extreme programming*) na década de 90, tal técnica propõe a identificação de requisitos através de textos curtos escritos em linguagem natural. Antes do surgimento das histórias de usuário já havia um estudo da década de 50 sobre o processamento da linguagem natural, que é uma vertente da inteligência artificial que lida com a classificação e interpretação de textos. O objetivo deste trabalho é demonstrar as propostas apresentadas na literatura científica atual sobre a aplicação do processamento de linguagem natural em histórias de usuário. Portanto foi realizado uma revisão sistemática de literatura, considerando publicações realizadas a partir do ano de 2018, onde os resultados encontrados foram trabalhos que apresentam o uso do processamento de linguagem natural no contexto de engenharia de requisitos

Palavras-Chave: Processamento de linguagem natural, Histórias de usuário, Engenharia de requisitos.

Abstract

User Stories is a technique of agile methodology that emerged from the XP method (extreme programming) in the 90s, such a technique proposes an identification of requirements through short texts written in natural language. Before the existence of user stories, there was already a study from the 1950s on natural language processing, which is a branch of artificial intelligence that deals with the description and interpretation of texts. The objective of this work is to demonstrate the proposals presented in the current scientific literature on the application of natural language processing in user stories. Therefore, a systematic literature review was carried out, considering publications made from the year 2018, where the results found were works that present the use of natural language processing in the context of requirements engineering.

Keywords: Natural language processing, User stories, Requirements engineering.

1. Introdução

Segundo o SWEBOK (2004), a história de usuário é uma técnica da metodologia ágil, que se refere a descrições curtas e expressas nos termos do cliente (linguagem natural) como forma de extrair requisitos de software. Uma história de usuário deve conter somente as informações necessárias para que os desenvolvedores possam estimar o tempo e esforço da implementação. Ela possui o seguinte *template*: Eu [persona], desejo [necessidade], para [propósito].

Refere-se linguagem natural, a linguagem utilizada por uma comunidade para comunicação no dia a dia assim como: Português, Francês, Inglês. A linguagem natural pode ser expressa através de símbolos ou textos, estes possuem um conjunto de prescrições e regras que determinam o uso correto do mesmo (gramática).

Na inteligência artificial existe uma área que lida com o processamento de textos livres escritos em linguagem natural, este é conhecido como processamento de linguagem natural ou linguística computacional. Segundo Russell, Stuart J (2013), a aplicação do processamento de linguagem natural visa acelerar o processo de análise, segmentação, classificação, recuperação e extração de informações de um texto escrito em linguagem natural.

A motivação deste trabalho é a possibilidade de redução de tempo e recursos, tendo em vista que ao aplicar o processamento de linguagem natural nas histórias de usuário, será possível com base no processamento da mesma, corrigir, validar e criar diagramas ou documentos que possam auxiliar a engenharia de requisitos e de *software*.

Este trabalho apresenta os resultados de uma revisão sistemática de literatura conduzida com o intuito de contribuir com a compreensão das propostas atuais da aplicação do processamento de linguagem natural nas histórias de usuário.

O restante do trabalho descreve o processo de revisão sistemática de literatura

realizada que está da seguinte forma. Na seção 2 é apresentado o protocolo de revisão sistemática que foi utilizado na condução deste trabalho. A seção 3 apresenta a condução do trabalho, e a forma como o protocolo foi seguido para a realização da revisão sistemática. A seção 4 trará as conclusões, respondendo as questões de pesquisa e apresentando a pontuação de cada trabalho.

2. Protocolo de Revisão Sistemática de Literatura

O trabalho de revisão sistemática de literatura foi feito utilizando o *software* de apoio Parsifal® [4] como ferramenta de apoio. O estudo foi conduzido com a busca de trabalhos relacionados ao tema através da *string* de busca em três bancos de dados de artigos online (motores / máquinas de busca): Science@Direct [3], IEEE Xplore [2], ACM Digital Library [1].

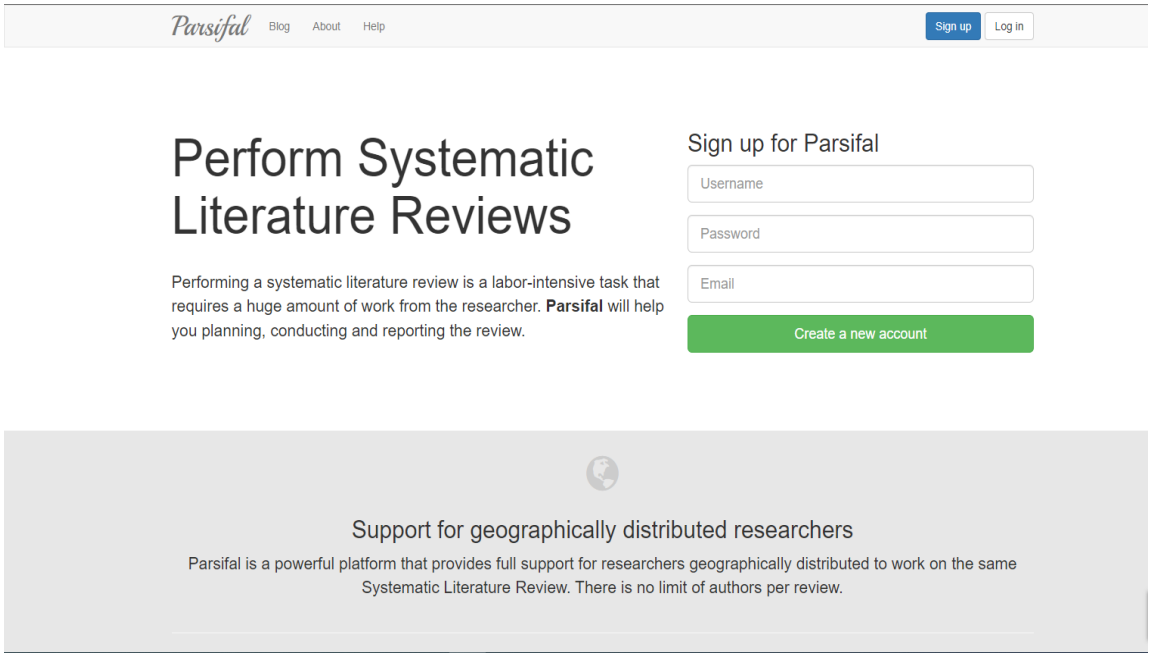

Imagem 1. Tela Principal do Parsifal®. Fonte: O autor.

O Parsifal® [4], auxiliou na criação das strings de busca a partir da população, intervenção e resultados definidos, assim como também possibilitou a importação dos estudos para a ferramenta de apoio, através do BibTeX gerado por cada base de dados.

Também favoreceu na seleção, classificação, busca por trabalhos duplicados em bases de dados diferentes e avaliação dos estudos encontrados. Este também permitiu salvar todas as informações relacionadas ao trabalho na própria ferramenta de apoio, tais como critérios de inclusão / exclusão, questões de pesquisa, questões da análise de qualidade, trabalhos aceitos e critérios utilizados para cada trabalho.

2.1. Questões de Pesquisa

A partir da orientação do artigo (Kitchenham, 2004), foram realizadas as definições dos parâmetros população, intervenção e resultados. Tendo como objetivo encontrar trabalhos que apresentam a utilização do processamento de linguagem natural aplicada as histórias de usuário, foram definidos os parâmetros da seguinte forma:

- População: Artigos científicos sobre técnicas da Inteligência Artificial para realizar análise de requisitos;
- Intervenção: Processamento de linguagem natural em histórias de usuário;
- Resultados: Abordagem do uso do processamento de linguagem natural em histórias de usuário para especificar ou analisar requisitos.

Após a definição destes parâmetros, foram também definidas as questões de pesquisa para nortear a metodologia deste estudo. São elas:

Q1: Houve uma redução significativa de tempo na análise de requisitos ao aplicar o processamento de linguagem natural nas histórias de usuário?

Q2: Os estudos publicados apresentam alguma limitação?

Q3: De que maneira o uso da técnica de processamento de linguagem natural em histórias de usuário pode impactar a especificação e análise de requisitos?

Q4: Porque aplicar o processamento de linguagem natural em histórias de usuário?

2.2. Palavras-chave para Pesquisa

A partir dos parâmetros anteriormente definidos, foi necessário escrever os sinônimos das palavras que estão em português para inglês, visando ampliar a pesquisa para todos os trabalhos escritos em inglês, ficando da seguinte forma:

Resultados: "Abordagem do uso do processamento de linguagem natural em histórias de usuário para especificar ou analisar requisitos" = "*A natural language processing approach in user stories to specify or analyze requirements*"

Intervenção: "Processamento de linguagem natural em histórias de usuário" = "*Natural language processing in user stories*"

População: "Técnicas de IA para realizar análise de requisitos" = "*Artificial intelligence techniques to perform requirements analysis*"

Após a definição dos sinônimos, a ferramenta de apoio Parsifal® gerou as seguintes palavras-chave:

("Técnicas de IA para realizar análise de requisitos" OR "*Artificial intelligence techniques to perform requirements analysis*") AND ("Processamento de linguagem natural em histórias de usuário" OR "*Natural language processing in user stories*") AND ("Abordagem do uso do processamento de linguagem natural em histórias de usuário para especificar ou analisar requisitos" OR "*A natural language processing approach in user stories to specify or analyze requirements*")

Porém ao aplicar esta sentença nas bases de dados, foi observado que os resultados traziam uma quantidade excessiva de trabalhos no qual muitos dos trabalhos retornados não havia uma relação com o tema de interesse proposto por esta revisão.

Portanto, na tentativa de retornar resultados satisfatórios foram definidas as palavras chave somente em inglês, da qual retornou um resultado satisfatório tanto na relação com o tema proposto quanto na forma quantitativa, comparado com a busca anterior. Ficando então da seguinte forma:

("Artificial intelligence techniques to perform requirements analysis") AND ("Natural language processing in user stories") AND ("A natural language processing approach in user stories to specify or analyze requirements")

As palavras chaves também foram personalizadas para cada base de dados, tendo em vista que para cada base de dados, ou havia uma quantidade excessiva de trabalhos, ou uma quantidade insuficiente. Por tanto para as bases de dados Science@Direct [3] e ACM Digital Library [1] permaneceram como “(Artificial intelligence techniques to requirement analysis) AND (Natural language processing in user stories) AND (A natural language processing approach in user stories to specify or analyze requirements)”, já na IEEE Xplore [2], as palavras chaves foram colocadas da seguinte forma “(*Artificial intelligence*

techniques for requirement analysis OR Natural language processing in user stories AND A natural language processing approach in user stories to specify or analyze requirements)”.

Ainda assim com estas chaves, os trabalhos não estavam retornando conteúdos completamente ligados ao tema proposto, portanto as palavras chaves foram refeitas de acordo com a orientação de cada base de dados, o que por fim trouxe um resultado ainda mais satisfatório. ficando da seguinte forma:

- Science@Direct [3]: *("Artificial intelligence") AND ("Natural language processing") AND (("User stories" AND "Software requirements" AND "Software engineering") OR ("Requirements analysis" AND "Requirements specification")).*
- ACM Digital Library [1]: *("Artificial intelligence") AND ("Natural language processing") AND (("User stories" AND "Software requirements" AND "Software engineering") OR ("Requirements analysis" AND "Requirements specification")).*
- IEEE Xplore [2]: *("Artificial intelligence") AND ("Natural language processing") AND (("User stories" AND "Software requirements" AND "Software engineering") OR ("Requirements analysis" AND "Requirements specification")).*

Outro fato importante foi a busca por publicações na ACM Digital Library [1], que foi feita em duas fontes da própria, ao submeter a string de busca, esta apresentou um outro link que levou a outros artigos que estavam relacionados a string submetida, estas duas fontes são: “*ACM Full-Text Collection*” e “*The ACM Guide to Computing Literature*”.

2.3. Critério de Inclusão e Exclusão

Os critérios de inclusão e exclusão visam filtrar os trabalhos que tratam de maneira concisa o tema do trabalho, excluindo os que não estão de acordo com o tema ou cenário proposto para a elaboração da pesquisa.

Inicialmente foram definidos critérios de inclusão que limitassem a utilização da inteligência artificial aplicada nas histórias de usuário ou em especial a utilização do processamento de linguagem natural aplicadas a histórias de usuário ou em outra parte da engenharia de requisitos.

1. Critérios de Inclusão:
    1. Trata de inteligência artificial aplicada a histórias de usuário.
    2. Trata do processamento de linguagem natural aplicada a engenharia de requisitos.
    3. Tratar de processamento de linguagem natural aplicada a histórias de usuário.
2. Critérios de Exclusão:
    1. Não aborda o uso de inteligência artificial.
    2. Não aborda processamento de linguagem natural.
    3. Não aborda histórias de usuário.
    4. Não é um estudo primário.
    5. Publicação anterior a 2018.
    6. Texto completo do trabalho não disponível de forma livre.
    7. Trabalho não está relacionado a histórias de usuário.
    8. Trabalho não está relacionado a processamento de linguagem natural.

A utilização do primeiro critério de inclusão “Trata da inteligência artificial aplicada em histórias de usuário”, foi criada, porque após aplicar as palavras chave nos

motores de busca, incluindo somente o processamento de linguagem natural, foi retornada uma baixa quantidade de trabalhos utilizando o mesmo, portanto com o intuito de englobar também outras técnicas da inteligência artificial, foi adicionado tal critério de inclusão, o mesmo aconteceu para as histórias de usuário, portanto com o intuito de abordar também outras técnicas da engenharia de requisitos, foi adicionado o segundo critério "Trata do processamento de linguagem natural aplicada a engenharia de requisitos".

A técnica utilizada é similar à técnica do artigo (Kitchenham, 2004) que fala a respeito do desenho experimental, porém neste caso o que aconteceu foi o inverso, contrariamente a grande quantidade de trabalhos serem um problema, a escassez de trabalhos que abordem inteligência artificial ou processamento de linguagem natural aplicadas a histórias de usuário que se tornou uma barreira.

3. Realização da Revisão Sistemática

A aplicação do protocolo de revisão sistemática definido na seção anterior foi realizada no período de agosto a março de 2023. A condução foi feita por um pesquisador iniciante orientado por um pesquisador experiente.

3.1. Seleção e Importação de Estudos

Foram encontrados 591 estudos utilizando a string de busca anteriormente discutida, juntamente com um filtro de data de publicação igual ou superior a 2018. O **Gráfico** 1 apresenta a quantidade de trabalhos retornados por cada base de dados, sendo a ACM Digital Library [1] a que mais retornou trabalhos. Foram 226 da ACM Digital Library [1], 157 da IEEE Xplore [2], e 208 da Science@Direct [3].

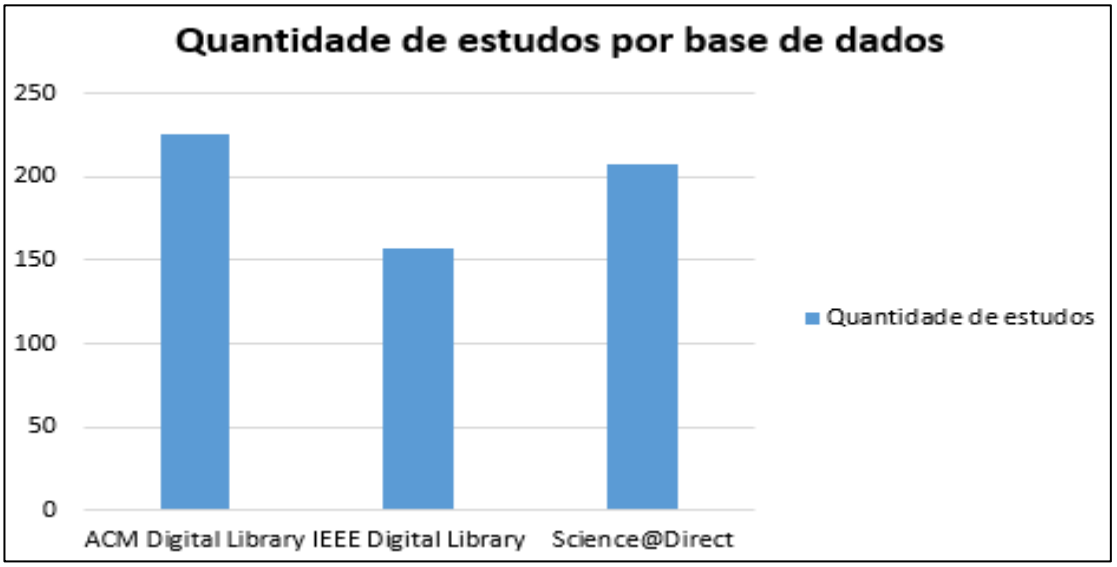

Gráfico 1. Quantidade de artigos retornados pelas bases de dados. Fonte: O autor.

Do total de 591, o ano onde se obteve mais publicações relacionadas à chave de busca informada, foi o ano de 2022 que retornou 154 publicações, como mostra o gráfico 2.

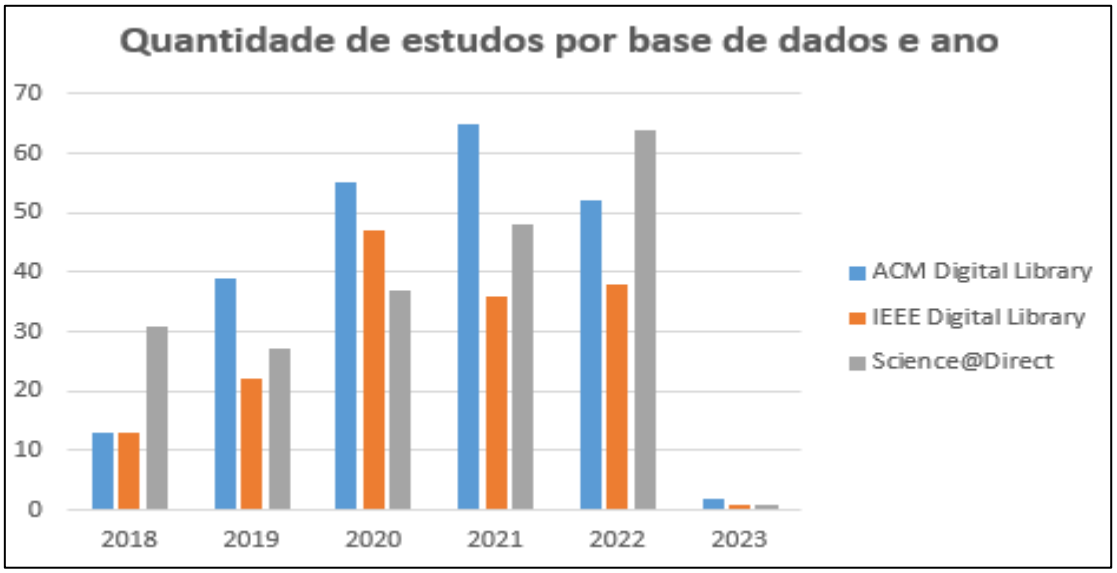

Gráfico 2. Quantidade de artigos retornados pelas bases de dados por ano. Fonte: O autor.

O Gráfico 3 apresenta a quantidade de trabalhos recuperados por ano de publicação. Em 2022 foram recuperados 154 artigos, sendo 25 deles duplicados, ou seja,

foram encontrados em mais de uma base de dados. No ano de 2020 foram obtidos 139 estudos, onde são 23 duplicados, 114 rejeitados, e 2 aceitos.

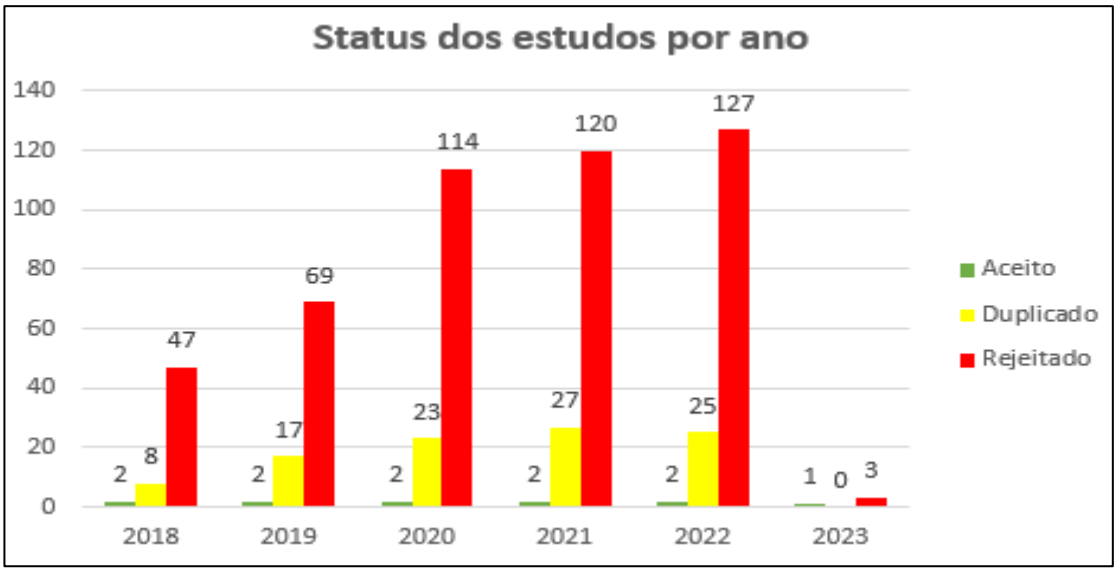

Gráfico 3. Quantidade de artigos aceitos, rejeitados e duplicados por ano. Fonte: O autor.

A base de dados que teve mais publicações aceitas com base nos parâmetros informados foi a ACM Digital Library [1]. Na base da IEEE Xplore [2], de 157 publicações nenhuma atendeu aos critérios de inclusão como mostra o Gráfico 4.

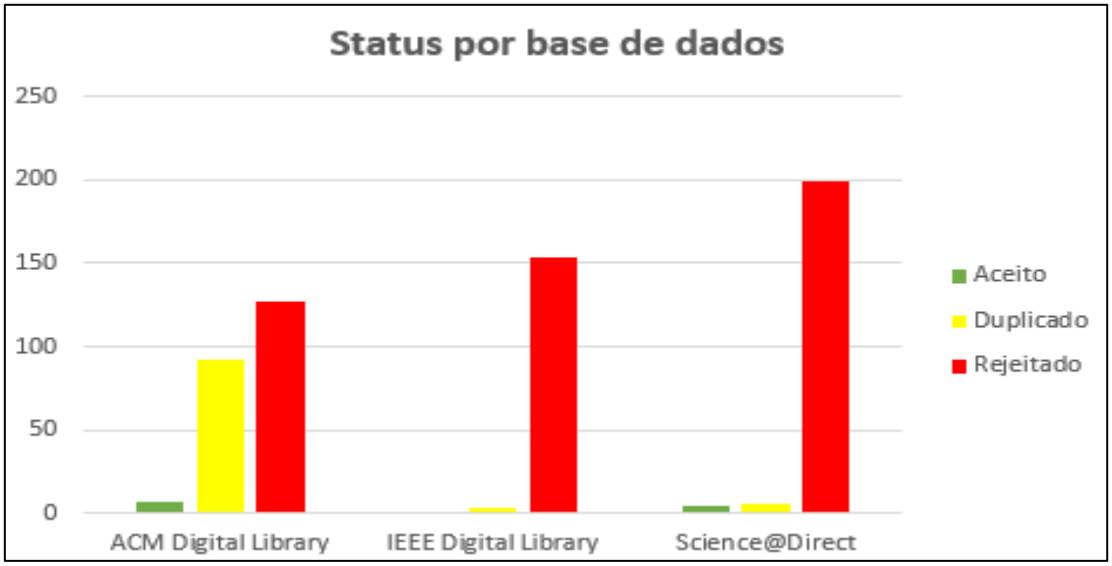

Gráfico 4. Quantidade de artigos aceitos, rejeitados e duplicados por base de dados. Fonte:

O autor.

Das publicações encontradas, um dos critérios de exclusão que mais coincidiu com uma grande parte dos trabalhos foi o critério de exclusão 7 (Trabalho não está relacionado a histórias de usuário), como mostra o gráfico 5. Nenhuma publicação foi excluída por não abordar o uso de inteligência artificial, por não possuir um resultado final, por não ser disponível de forma livre, ou ser uma publicação anterior a 2018.

Gráfico 5. Quantidade de artigos rejeitados, por critério de exclusão. Fonte: O autor.

A Tabela 1 apresenta as 480 publicações rejeitadas com base nos critérios de exclusão.

Critério de Exclusão	**Trabalhos Excluídos**
7	[17], [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29], [30], [32], [33], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45], [46], [47], [48], [49], [50], [51],

	[52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65], [66], [67], [68], [69], [70], [71], [72], [73], [74], [75], [76], [77], [78], [79], [80], [81], [82], [83], [84], [85], [86], [89], [90], [93], [95], [96], [97], [98], [99], [100], [101], [102], [103], [105], [106], [107], [108], [110], [111], [112], [113], [115], [116], [117], [118], [119], [120], [121], [122], [123], [124], [125], [126], [127], [128], [129], [130], [131], [132], [133], [134], [135], [136], [137], [138], [139], [140], [141], [142], [143], [144], [145], [146], [147], [148], [149], [150], [151], [152], [153], [154], [155], [156], [157], [159], [160], [161], [162], [163], [164], [165], [166], [167], [168], [169], [170], [171], [172], [173], [174], [175], [176], [177], [178], [179], [180], [181], [182], [183], [185], [186], [187], [188], [189], [190], [191], [192], [193], [194], [195], [196], [198], [199], [200], [201], [202], [205], [206], [207], [208], [209], [210], [211], [212], [213], [214], [215], [216], [217], [218], [219], [220], [221], [222], [223], [224], [225], [226], [227], [228], [229], [230], [232], [234], [235], [236], [237], [238], [240], [241], [242], [243], [244], [245], [246], [247], [248], [249], [250], [251], [252], [253], [254], [255], [256], [257], [258], [259], [260], [261], [262], [263], [264], [265], [266], [267], [268], [269], [270], [271], [272], [273], [274], [275], [276], [277], [278], [279], [280], [281], [282], [283], [284], [285], [286], [287], [288], [289], [290], [291], [292], [293], [294], [295], [296], [297], [298], [300],

	[301], [302], [303], [304], [306], [307], [308], [309], [310], [311], [312], [313], [314], [315], [316], [317], [318], [319], [320], [321], [322], [323], [324], [325], [326], [327], [328], [329], [330], [331], [332], [333], [334], [335], [336], [337], [338], [339], [340], [341], [342], [343], [344], [345], [346], [347], [348], [349], [350], [351], [352], [353], [354], [355], [356], [357], [358], [359], [360], [361], [362], [363], [364], [365], [366], [367], [368], [369], [370], [371], [372], [373], [374], [375], [376], [377], [378], [379], [380], [381], [382], [383], [384], [385], [386], [387], [388], [389], [390], [391], [392], [393], [394], [395], [397], [398], [400], [401], [402], [403], [404], [405], [406], [407], [408], [409], [410], [411], [412], [413], [414], [415], [416], [417], [418], [419], [420], [421], [422], [423], [424], [425], [426], [427], [428], [431], [432], [433], [434], [435], [436], [437], [438], [439], [441], [442], [443], [444], [445], [446], [447], [449], [450], [451], [452], [453], [454], [455], [456], [458], [459], [460], [461], [462], [463], [464], [465]
4	[18], [87], [91], [92], [94], [109], [114], [158], [184], [197], [204], [231], [233], [239], [430], [440], [448], [457], [466], [467], [468], [469], [470], [471], [472], [473]
8	[203], [299], [305], [396], [399], [474]
2	[31], [88], [104], [429], [475]
1	[476]
3	[477], [478], [479], [480], [481], [482], [483], [484], [485],

	[486], [487], [488], [489], [490], [491], [492], [493], [494], [495], [496], [497]

Tabela 1. Conjunto dos trabalhos não aceitos

A tabela 2 apresenta os trabalhos aceitos e o critério para aceitação do mesmo.

Critério de Aceitação	**Trabalhos Aceitos**
1	[12], [16], [498], [499]
2	[11], [13], [14], [15]
3	[8], [9], [10]

Tabela 2. Conjunto dos trabalhos aceitos

3.2. Síntese dos Estudos Aceitos

Os trabalhos aceitos desta revisão de literatura dividem-se em três grupos, baseados em tópicos específicos abordados por estes. Pode se notar por exemplo que os trabalhos '*Automatic Transformation of User Stories into UML Use Case Diagrams Using NLP Techniques*'[12], '*An Approach to Identify Use Case Scenarios from Textual Requirements Specification*' [14] e '*The Use of Artificial Neural Networks for Extracting Actions and Actors from Requirements Document*' [13], todos tratam da utilização do processamento de linguagem natural no contexto de engenharia de requisitos, porém, lidam com tal de formas diferentes. Por exemplo, o primeiro trabalho citado trata especificamente do processamento em histórias de usuário, enquanto o segundo e o terceiro não apresentam tratar do processamento de linguagem natural unicamente em histórias de usuário, mas sim em documentos de requisitos no geral.

No primeiro grupo dos estudos aceitos, estão artigos que discorrem sobre a utilização do processamento de linguagem natural exclusivamente em histórias de usuário. No segundo grupo os artigos tratam sobre a aplicação do processamento de linguagem natural em outros documentos de requisitos, e por fim no terceiro grupo estão os artigos que utilizam outras técnicas de inteligência artificial em conjunto ou não com o processamento de linguagem natural no contexto de engenharia de requisitos.

No total de 591 artigos, 11 destes foram aceitos, onde 5 destes tratam do processamento de linguagem natural em histórias de usuário, 4 tratam do mesmo processamento, porém em outros documentos de requisitos e os outros 2 trabalhos tratam do processamento de linguagem natural em conjunto com outras técnicas de IA, sendo elas redes neurais e aprendizado de máquina. Os outros artigos ficaram divididos entre 100 duplicados e 480 rejeitados.

3.2.1. Processamento de linguagem natural em histórias de usuário

O trabalho '*Automatic Transformation of User Stories into UML Use Case Diagrams Using NLP Techniques*'[12] apresenta a utilização de uma das técnicas do processamento de linguagem natural, com o intuito de criar diagramas de caso de uso UML com o texto processado. O trabalho tem como fundamento pré-processar e filtrar palavras não necessárias das histórias de usuário e após isso enviá-las para o *TreeTagger* (Uma ferramenta de processamento de linguagem natural que é amplamente utilizada para a marcação morfossintática de palavras em um texto). Este trabalho afirma que a utilização do mesmo pode impactar positivamente na engenharia de requisitos porque permite retirar do time responsável pelos requisitos ou engenheiro de requisitos a responsabilidade de transformar as histórias de usuário em um diagrama de caso de uso UML, além de reduzir a ambiguidade das especificações de requisitos, o que responde a 3º e 4º questão de pesquisa.

'*Detecting Terminological Ambiguity in User Stories: Tool and Experimentation*' [10] propõe a utilização do processamento de linguagem natural para detecção de ambiguidade terminológica. Este trabalho tem como objetivo impactar de maneira positiva a prática de engenharia de requisitos e tem como abordagem a utilização da ferramenta Cortical.io. Esta ferramenta aplica conceitos do processamento de linguagem natural e é baseada no processo de redução semântica, que emprega um modelo matemático de linguagem para capturar a essência de palavras e textos. Ela realiza esse processamento utilizando algumas técnicas como análise morfológica, análise sintática e análise semântica. Assim como o trabalho anterior, este também responde a algumas questões de pesquisa, mostrando-se promissor em identificar a ambiguidade em histórias

de usuário e assim poupar tempo e esforços manuais para detecção e correção, portanto esse responde a 1º pergunta, já que este reduz o tempo para detectar ambiguidade e assim possibilitar que uma história de usuário seja escrita de forma precisa, concisa e não ambígua.

'*Learning Software Requirements Syntax: An Unsupervised Approach to Recognize Templates'* [16] apresenta um trabalho que tem o intuito de reconhecer modelos e sintaxe de requisitos. O trabalho apresenta de forma detalhada as técnicas do processamento de linguagem natural utilizadas, da mesma maneira que discorre sobre o algoritmo hierárquico de detecção de comunidade. O mesmo mostra que as histórias de usuário foram bem detectadas pelo trabalho, isso acontece devido as restrições necessárias para redigir uma história de usuário.

'*Towards a Generation of Class Diagram from User Stories in Agile Methods'* [9] tem como objetivo, gerar diagramas de classes através das histórias de usuário em metodologias ágeis. Ele apresenta de forma minuciosa a utilização da ferramenta desenvolvida pela Universidade Stanford 'Stanford CoreNLP', na qual a implementação foi desenvolvida em python. O trabalho demonstra que a utilização do que foi proposto, pode impactar positivamente a área de engenharia de requisitos pois possibilita o gerenciamento de forma satisfatória dos substantivos compostos para extração de classe e visa facilitar o design das tarefas analíticas da equipe de projeto em uma abordagem de '*Model-Driven Architecture*' (arquitetura orientada a modelo), e afirma que isso pode otimizar o tempo e rentabilizar o custo em projetos ágeis, o que responde a 4º questão de pesquisa.

'*User Story Clustering in Agile Development: A Framework and an Empirical Study'* [8] consiste em gerar agrupamentos '*clusters*' de histórias de usuário, utilizando técnicas de clusterização e de processamento de linguagem natural. O trabalho apresenta

com poucas palavras a aplicação da filtragem de ‘stop worlds’ e propõe uma nova ferramenta que é chamada de ‘CUSNLP’, que é a junção de cluster com processamento de linguagem natural. Por fim o trabalho apresenta os agrupamentos com base em grafos conexos e indica que o trabalho possui uma elevada precisão e que é capaz de extrair classes de tarefa e estruturas verbo-objeto e não-objeto para representar uma história de usuário de forma rápida e nítida.

3.2.2. Processamento de linguagem natural em documentos de requisitos

‘*An Approach to Identify Use Case Scenarios from Textual Requirements Specification’* [14] demonstra o uso de algumas técnicas de processamento de linguagem natural em documentos de caso de uso. O trabalho detalha como é feita a identificação do nome do caso de uso, dos atores primários e secundários, dependências do caso de uso, pré-condições, do fluxo primário de eventos, fluxo de eventos alternativo e pós condições. Por fim o trabalho demonstra que a abordagem proposta visa cuidar e garantir que a especificação do caso de uso, será completa, consistente, exata e não redundante com a lista de verificação, além também de fornecer um questionário gerado automaticamente pela ferramenta, que pode auxiliar na garantia da derivação da especificação de qualidade, o que também responde a 3º e 4º questão de pesquisa.

‘*Expanding Normalized Systems from Textual Domain Descriptions Using TEMOS’* [498] apresenta a utilização de diversas técnicas de processamento de linguagem natural, para transformar informações textuais em modelos internos, e visa processar requisitos funcionais e transformá-los em sistemas de informação utilizando tanto o processamento de linguagem natural quanto sistemas normalizados e outros recursos apresentados como por exemplo o TEMOS. Este trabalho é a continuidade de outros trabalhos do mesmo autor, porém neste o objetivo é entregar um sistema de informação a

partir das informações textuais.

‘*Generating UML Use Case and Activity Diagrams Using NLP Techniques and Heuristics Rules’* [15] expõe diversas técnicas e ferramentas de processamento de linguagem natural, o trabalho visa gerar diagramas UML através de requisitos informais escritos em linguagem natural, isso pode ajudar a reduzir custos e esforços, tendo em vista que a atual forma de criar diagramas UML é através da análise manual dos requisitos, o que pode gerar problemas com a interpretação e dificuldades em recuperar os mesmos, e a qualidade dependerá do conhecimento do domínio do profissional que estará analisando os requisitos. Este trabalho é similar ao trabalho ‘*Automatic Transformation of User Stories into UML Use Case Diagrams Using NLP Techniques*‘[12]. A diferença principal entre os dois está nos documentos de requisitos necessários para gerar um diagrama de caso de uso UML, onde um está abordando a geração do diagrama de caso de uso UML a partir das histórias de usuário e o outro a partir de requisitos informais.

‘*Knowledge Extraction from Natural Language Requirements into a Semantic Relation Graph’* [11] retrata uma abordagem de extração de conhecimento através da utilização de relações semânticas entre partes da linguagem natural que são armazenadas em um grafo de conhecimento. O trabalho apresenta a maneira de como foram utilizadas as técnicas de processamento de linguagem natural, assim como as ferramentas utilizadas para tal feito, como o Stanford core nlp. Por fim o trabalho informa que para a aplicação do mesmo é necessário apenas um único requisito, que é, ter o conteúdo escrito na língua inglesa.

3.2.3. Processamento de linguagem natural e Inteligência Artificial

‘*The Use of Artificial Neural Networks for Extracting Actions and Actors from Requirements Document’* [13] propõe uma abordagem para a extração de casos de uso

com seus atores e ações, utilizando o processamento de linguagem natural em conjunto com redes neurais artificiais. O trabalho demonstra a utilização de duas ferramentas como base para o processamento da linguagem natural, o ANNIE (*Almost-Nottingham Information Extraction System*) e o Stanford CoreNLP. O tipo de rede neural artificial utilizada por este trabalho foi a rede neural de retro propagação, e esta foi treinada utilizando a estratégia de treinamento supervisionado e aprendizado de retro propagação a partir de um algoritmo apresentado no artigo em questão.

'*Model Transformation Development Using Automated Requirements Analysis, Metamodel Matching, and Transformation by Example'* [499] exibe a utilização do processamento de linguagem natural e também de aprendizado de máquina para realizar a transformação de modelos, que é um elemento chave da engenharia dirigida por modelo. O trabalho também expõe que a combinação do aprendizado de máquina com o processamento de linguagem natural, pode ser útil na formalização de requisitos, onde as informações linguísticas detalhadas da análise de tal processamento podem ser fornecidas como entradas para o processo de aprendizado de máquina. Por fim é apresentado no trabalho que o mesmo é capaz de inferir transformações relevantes, eficientes e com design consistente.

3.3. Análise de Qualidade dos Estudos Aceitos

Foi observado que os trabalhos aceitos estão divididos entre os que aplicam o processamento de linguagem natural em histórias de usuário, e dos que aplicam tal processamento em outros tipos de documento de requisitos, ou até mesmo em textos livres.

Foi possível notar que a grande maioria dos trabalhos utilizaram como ferramenta o Stanford CoreNLP, porém poucos trabalhos fizeram o uso de outras técnicas de

inteligência artificial em conjunto com as técnicas de processamento de linguagem natural, o que demonstra que por algum motivo os trabalhos se limitaram a não utilizar o processamento de linguagem natural em conjunto com outras técnicas de inteligência artificial, o que responde a 2º questão de pesquisa.

Os trabalhos aceitos todos detalharam como foi implementado o processamento de linguagem natural, e quais técnicas foram utilizadas. Os mesmos também apresentaram como objetivo, contribuir com a área de análise de requisitos, sempre com o intuito de reduzir tempo e esforço.

Os critérios de qualidade definidos foram:

1. O estudo aborda a utilização do processamento de linguagem natural de forma clara e detalhada?
2. O estudo apresenta a utilização do processamento de linguagem natural nas histórias de usuário para algum fim na análise de requisitos?
3. O estudo apresenta a utilização de alguma outra técnica de inteligência artificial, em conjunto com o processamento de linguagem natural?
4. O estudo apresenta a utilização de alguma ferramenta de apoio para a elaboração do mesmo?

Onde:

- [8] cumpre a todos os critérios, exceto critérios 3 e 4.
- [9], [10], [12] e [16] cumprem a todos os critérios, exceto critério 3.
- [11], [14], [15] e [498] cumprem a todos os critérios, exceto ao critério 2 e 3.
- [13] cumpre a todos os critérios, exceto ao critério 2.
- [499] cumpre a todos os critérios, porém cumpre parcialmente ao critério 2.

4. Conclusões

Pode-se deduzir da pesquisa examinada que a utilização do processamento de linguagem natural ao lidar com histórias de usuários ou documentos de requisitos pode fornecer vantagens notáveis na análise de requisitos. Evidências mostram que técnicas como identificação de modelos e sintaxe, produção de diagramas de caso de uso UML, reconhecimento de ambiguidade terminológica, agrupamento e identificação de elementos em caso de uso permitem redução no tempo necessário para análise e melhoria na qualidade da especificação de requisitos, como apresentam os trabalhos '*Detecting Terminological Ambiguity in User Stories: Tool and Experimentation*' [10], '*User Story Clustering in Agile Development: A Framework and an Empirical Study'* [8], '*Generating UML Use Case and Activity Diagrams Using NLP Techniques and Heuristics Rules'* [15] e '*Automatic Transformation of User Stories into UML Use Case Diagrams Using NLP Techniques*'[12]

O emprego de ferramentas de processamento de linguagem natural é recomendado para encurtar o tempo necessário para conduzir a análise de requisitos em projetos ágeis. Isso não apenas reduz o custo, mas também aprimora a prática de engenharia de requisitos, garantindo uma especificação de caso de uso abrangente, coerente e precisa como afirma o trabalho '*An Approach to Identify Use Case Scenarios from Textual Requirements Specification'* [14]. Estudos têm mostrado que as ferramentas de processamento de linguagem natural são altamente eficazes na obtenção desses resultados.

Outras técnicas de inteligência artificial recebem menos foco em estudos com muitos não fornecendo informações suficientes sobre como foram usadas ou suas limitações em contextos variados. É possível notar que no total de 11 trabalhos aceitos, somente os trabalhos '*The Use of Artificial Neural Networks for Extracting Actions and Actors from Requirements Document*' [13] e '*Model Transformation Development Using*

Automated Requirements Analysis, Metamodel Matching, and Transformation by Example' [499], abordaram o uso de outras técnicas de inteligência artificial em conjunto com o processamento de linguagem natural, o que demonstra que ainda é possível explorar outras técnicas em conjunto com a mesma.

As histórias de usuário são a principal área em que as técnicas de processamento de linguagem natural são aplicadas, mas muitos estudos não se aprofundam nas maneiras pelas quais outras técnicas são usadas. Essas limitações dificultam a avaliação completa da eficácia dessas técnicas em diferentes situações.

Trabalhos futuros:

- Investigar outras áreas de aplicação do PLN; embora as técnicas de PLN tenham sido amplamente utilizadas nas histórias de usuário, existem outras áreas na engenharia de requisitos que podem se beneficiar dessa técnica.
- Avaliar a eficácia em diferentes situações, embora a pesquisa demonstre que as ferramentas de PLN são extremamente eficazes, é fundamental entender como funcionam em vários contextos.

A otimização do tempo e a melhoria da qualidade da especificação são benefícios significativos que os aplicativos de processamento de linguagem natural em histórias de usuários podem trazer para a análise e especificação de requisitos. No entanto, na engenharia de requisitos, outras aplicações de técnicas de inteligência artificial exigirão mais exames e pesquisas.

Uma contribuição notável desta revisão sistemática para a área acadêmica, foi a aplicação do desenho experimental de forma inversa, o que permitiu a avaliação dos trabalhos que estão no grupo dos trabalhos que aplicaram o processamento de linguagem natural em conjunto com outras técnicas de IA, assim como os que aplicaram tal processamento em outros documentos de requisitos.

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