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Modeling workflow to design machine translation applications for public health practice

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ABSTRACT

Objective: Provide a detailed understanding of the information workflow processes related to translating health promotion materials for limited English proficiency individuals in order to inform the design of context-driven machine translation (MT) tools for public health (PH).
Materials and methods: We applied a cognitive work analysis framework to investigate the translation information workflow processes of two large health departments in Washington State. Researchers conducted interviews, performed a task analysis, and validated results with PH professionals to model translation workflow and identify functional requirements for a translation system for PH.
Results: The study resulted in a detailed description of work related to translation of PH materials, an information workflow diagram, and a description of attitudes towards MT technology. We identified a number of themes that hold design implications for incorporating MT in PH translation practice. A PH translation tool prototype was designed based on these findings.
Discussion: This study underscores the importance of understanding the work context and information workflow for which systems will be designed. Based on themes and translation information workflow processes, we identified key design guidelines for incorporating MT into PH translation work. Primary amongst these is that MT should be followed by human review for translations to be of high quality and for the technology to be adopted into practice.
Conclusion: The time and costs of creating multilingual health promotion materials are barriers to translation. PH personnel were interested in MT's potential to improve access to low-cost translated PH materials, but expressed concerns about ensuring quality. We outline design considerations and a potential machine translation tool to best fit MT systems into PH practice.

1. Introduction

Advances in machine translation (MT) technology have greatly increased its potential for improving access to multilingual health materials for limited English proficiency (LEP) populations in the US. However, publicly available MT systems (e.g., Google Translate, Bing Translator) traditionally perform poorly in the domain of public health (PH), an arena where clear and accurate communication of health messages to broad populations is crucial [1–3]. The need for multilingual health promotion materials is clear. According to the American Community Survey, 381 different languages are spoken in the US [4]. Nearly 20% of the population over 5 years of age speaks a language other than English at home, and 44% of those are categorized as LEP [4], which is defined as having a primary language other than English and a limited ability to read, write or understand English [5]. Minorities with LEP are at a higher risk for health disparities than English-speaking minorities, and have less access to health education, less preventive screening, and report poorer health statuses than English-speaking minority groups [6–8].

Federal regulations require that individuals have equal access to health information and thus all states have enacted laws to ensure that language barriers do not inhibit access to health and social services [9]. Despite these legal requirements, the cost and resources necessary to translate materials into other languages

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limits PH professionals' ability to produce them. Recent advances in MT technology have greatly increased the potential of using MT to facilitate and accelerate the production of multilingual health materials. However, a crucial prerequisite for the adoption of new technology is its smooth integration into existing workflow practices. For this reason, our team explored current PH translation processes to better understand how MT technology could successfully be applied to PH settings. Workflow studies were conducted using a cognitive work analysis framework to identify functional requirements for engineering software designed to improve the production of multilingual health education materials for PH practice [10,11]. Given the substantial financial constraints, competing needs, and diverse services of the more than 3000 local health departments in the United States, as well as the local rather than central funding streams, our goal was to design a system with freely available software tools that could be easily adopted in a variety of PH settings without expensive subscription costs and a need for negotiating ongoing contracts. These studies provided the foundation for designing a prototype collaborative MT tool called PHAST for use in PH practice.

1.1. MT and its potential use in public health settings

Over the last decade, MT technology has been greatly improved; it is now used by language providers and various companies, as well as by governmental and non-profit organizations. With statistical MT – which is presently the most promising approach – models are trained automatically using large bodies of parallel text or text in the source language paired with its translation in the target language [12]. A more detailed introduction to statistical MT technology can be found in Cancedda et al. [13].

Statistical MT has been shown to be more powerful than older approaches like rule-based MT and translation memories, which rely on sophisticated linguistic analyses or on large databases of stored examples that need to match the input text. Therefore, the best statistical MT systems typically outperform rule-based or example-based MT systems, even on specialized technical text (see e.g., [14]). However, it is generally recognized in the MT user community that MT engines still produce flawed output yet are often sufficient for text classification or gisting (creating a rough translation) tasks. More importantly, MT is most often used in combination with post-editing by a human reader, i.e., first-pass machine translations are manually corrected in a second pass by a human post-editor. This process has been shown to be significantly faster and less costly than having human translators create translations in an entirely manual process [15]. In the health domain, MT has been used for years by organizations such as the Pan-American Health Organization and the Canadian-UN Global Network for Public Health Intelligence [16,17]. By contrast, MT has only recently been introduced into local and regional health care and PH settings in the US [18,19]. Despite the growing need for multilingual health materials and the potential of MT to facilitate production of, and access to, these materials, there exists widespread skepticism among PH professionals about MT's ability to produce quality translations of health information [20]. There are many reasons for this. Firstly, the broad range of subject matters, diverse audiences, and criticality of clear communication of health messages make the PH domain particularly challenging with respect to MT. In addition, some concerns may derive from the perceived difficulty of language in PH documents. Work on natural language processing (NLP) methods for the related problem in biomedical or clinical text processing (see [21–24] for overviews) has shown that extensive adaptation of NLP tools is required in order to produce usable results; these include, among others, customized tools for part-of-speech tagging, named-entity recognition, event detection, and relation extraction [25–28].

In our past work we have studied the linguistic characteristics of typical PH documents intended for translation in a variety of PH departments [29,30]. These included web pages, flyers, and hand-outs on a variety of PH topics (e.g., vaccinations, specific diseases, food safety, etc.). These materials are typically intended for the general public and are required to be written at an 8th grade reading level. In practice, this is not always the case; documents often include specialized medical terms (e.g., "yersiniosis"), acronyms ("MRSA"), and other complexities that might be difficult to process for some human readers. At the syntactic level, information is often condensed into bulleted lists, enumerations, or multi-noun compounds (such as "waste clearance request form"). Nevertheless, the language of PH documents is not nearly as complex, technical, or ambiguous as that of biomedical literature or clinical texts, and is closer to everyday language.

In a detailed analysis of machine translations of 25 randomly selected PH documents into Spanish, we found that a generic MT engine (Google Translate) produced high-accuracy outputs: on a scale from 1 (worst) to 5 (best), the semantic adequacy of the translations (i.e., the correct translation of the content) was rated 4.19 on average; the grammatical fluency (correct syntax, word forms, etc.) was rated 3.73 on average [29]. Thus, we can expect current generic MT systems to provide a reasonable starting point for applications in the health domain.

1.2. Tailoring a MT system to public health practice

A second, equally important problem involves actually incorporating MT systems into PH practice. Information systems created for PH practice are often underutilized. This is due in part to information systems in PH being designed without a clear understanding of the context of PH work and information workflow [31–33]. Information systems that are poorly aligned with workflow are not well adopted and can produce negative results [31,34–36]. The goal of this study is to investigate current PH translation information workflow and processes in order to identify the functional requirements for an MT tool that can effectively be incorporated into PH workflow and practice.

We utilized principles from the Cognitive Work Analysis (CWA) framework to understand the goals, tasks, processes, and constraints associated with creating translations for LEP populations [37]. CWA is a valuable framework for understanding the context of complex work environments and the individuals who perform that work. We utilized this framework to investigate two large health departments in Washington State (WA) with the aim of identifying how MT systems can be designed to fit into current PH workflows through context-driven design of new technologies.

CWA is a framework derived from cognitive engineering in which work is explicitly analyzed to inform the design of technologies to support human work [37]. Through interviews, artifacts, informal observations, and participant feedback we used CWA principles to take into consideration the context in which the work is done, the environment, and the goals and values of the individuals performing the work. CWA has been used to inform the design of clinical physician order entry (CPOE) systems [38] and other clinical information systems [39,40]. Because information systems in PH are often underutilized, we hoped to improve utilization by better understanding the context in which PH translation work occurred. To our knowledge, CWA has not previously been applied to PH practice.

The studies reported here were designed to provide a better understanding of the information workflow involved in the creation and generation of multilingual health materials in PH, with the goal of informing the design of MT systems that meet the needs and work practices of PH agencies. The results of these studies led

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