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ScienceDirect

Procedia Manufacturing 11 (2017) 1303 – 1310

Procedia MANUFACTURING

27th International Conference on Flexible Automation and Intelligent Manufacturing, FAIM2017, 27-30 June 2017, Modena, Italy

From paper manual to AR manual: do we still need text?

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Abstract

In this work, we proposed a method to reduce text in technical documentation, aiming at Augmented Reality manuals, where text must be reduced as much as possible. In fact, most of technical information is conveyed through other means such as CAD models, graphic signs, images, etc.. The method classifies technical instructions into two categories: instructions that can be presented with graphic symbols and instructions that should be presented with text. It is based on the analysis of the action verbs used in the instruction, and makes use of ASD Simplified Technical English (STE) for remaining text instructions and let them easier to translate into other languages.

Peer-review under responsibility of the scientific committee of the 27th International Conference on Flexible Automation and Intelligent Manufacturing

Keywords: Augmented Reality; Industry 4.0; Technical Documentation; Visual; Simplified Technical English; Text reduction; Graphic symbols.

1. Introduction

In the words of German Chancellor Angela Merkel, Industry 4.0 is *the comprehensive transformation of the whole sphere of industrial production through the merging of digital technology and the internet with conventional*

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Peer-review under responsibility of the scientific committee of the 27th International Conference on Flexible Automation and Intelligent Manufacturing
doi:10.1016/j.promfg.2017.07.258

industry. In this transformation, also technical documentation is involved. Industry 4.0 promote the digitalization of it, with new visual manuals that gradually are introduced in the factories, where however paper manuals remain.

Visual manuals make use of digital technologies to acquire, store and display technical information. A key technology that it is going to be used for these manuals is Augmented Reality (AR) that reduce operator times and errors in the accomplishment of procedural tasks [1], [2]. Furthermore, there are specific industrial areas where the visualization of information through AR is very effectiveness respect to other technologies: examples are remote assistance [3], [4] and localization of points for inspections [5]. The digitalization of technical documentation implies the following advantages:

- Visual manuals are easy to update.
- Visual manuals have no storing problems: for paper manuals, more pictures mean more pages, weight and difficulty to use.
- Visual manuals are easy to translate in all languages.
- Visual manuals are easy to use.

These advantages are very appreciated by industrial companies, because their products change very quickly and then also technical documentation must be easy to update. Furthermore, products are sold all over the world and local customers need a documentation in their native language, then it is crucial to reduce the effort to translate manuals in any language.

To achieve all these advantages, the strategy used in the authoring of visual manuals is: less text, more graphics. In fact, strong reduction of text that means reduced effort to update manuals, less time to read for technicians, easier translation of the manual in other languages, comprehensibility and intuitiveness of the information, and scalability of the solution. All these benefits result in a strong cost reduction for companies.

However, industrial companies are still less ready to accept this innovation in their current procedures, and most of them still need paper manuals. A compromise should be that of convert their existing documentation into a digital format with an increasing diffusion of visual elements. In an initial evolution stage of the system, visual elements can be pictures or videos, but the goal is to go towards AR interfaces.

Authoring of technical documentation for AR visualization is a crucial problem, but it was very less addressed in the literature, and technical writers have few guidelines to follow.

Knöpfle and Weidenhausen [6] describe a concept to simplify the creation of AR based manuals, allowing also people without special AR and IT skills to carry out this task. The core idea is template based authoring: The editor of an AR based manual describes scenes at a very high and abstract level, for example “remove the v-belt”. The tool transforms this description into VRML-based statements including animations. The authors observed some limitations in the described method and stated that in future works they will separate the object description and information from the actual VRML file and store this information in a XML-based data format.

Stock et al. [7] proposed a metadata based authoring to generate technical documentation. The basic concept of metadata based authoring is the usage of information recorded during the entire design and development process of technical products. This information supports the technical writer in generating and maintaining operating instructions or repair manuals etc.

Gimeno et al. [8] proposed an AR authoring tool which provides advanced visual effect, such as occlusion or media contents. This tool allows non-programming users to develop low-cost AR applications, specially oriented to on-site assembly and maintenance/repair tasks. A new 3D edition interface is proposed, using photos and Kinect depth information to improve 3D scenes composition.

In all the previous approaches found in the literature, the use of AR is still based on the visualization of 3D models in the real scene. However, they did not consider the effort to create and place accurately these CAD models on the scene. Furthermore, also in AR interfaces, not all the contents should be processed in the same way: some instructions need more complex visual features, for others it is preferable to use only text. This is mainly due to the task complexity, as argued by Radkowski et al. [9]: they compared a concrete AR interface, which make use of 2D text, 3D models and animations, with an abstract AR interface, which instead make use of text, 3D arrows and 2D schemas. They found that for complex assembly operations, the concrete AR interface outperforms the abstract AR one, whereas for part and tool identification the two interfaces have the same performance. Then, for this last class of operations, it is not justified spend time and money for the authoring of a concrete AR interface.

In our study, we propose a method to convert existing technical documentation from a traditional display mode (much text, printed or PDF output), to a visual one (more graphics, digital output). We made this, thinking to the final target that is AR technical documentation.

2. Our method

2.1 The transition from traditional to visual technical documentation

With the diffusion of Industry 4.0 initiatives, we will assist to a transition from a traditional way to create technical documentation, based on word processing, with static contents and displayed on paper or digital manuals, to a novel way, based on visual elements, with interactive contents, displayed on advanced devices and where humans interact through Natural User Interfaces [10], [11]. This transition would happen following subsequent evolution steps (Fig. 1).

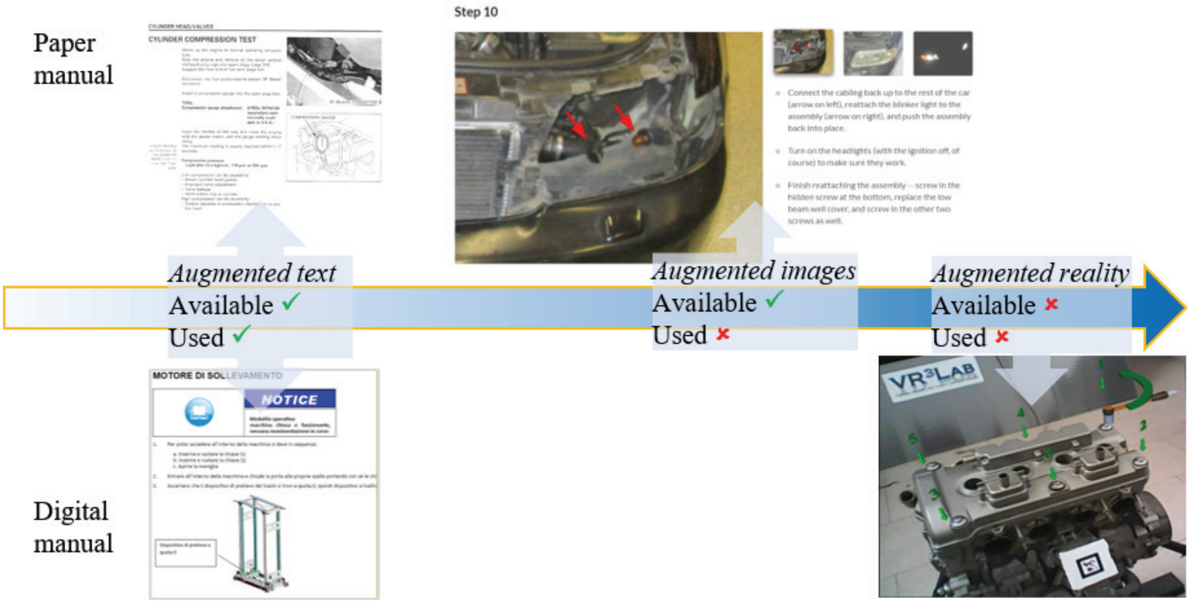

Fig. 1. Evolution of technical documentation, from paper manual to Augmented Reality manual.

Currently, the authoring of technical documentation in the industry is mainly based on an *augmented text* approach. The innovative aspect is only the conversion of existing traditional manuals into a digital format. Then, the creation starts from the information (mainly text) already available from previous manuals. The original instructions are analyzed, converted in the new format, and pasted in the new platform. This is the authoring strategy used by most of the commercial software for technical documentation (e.g., MadCap, Arbortext).

A first evolution step is accomplished with *augmented images* approach. It requires the rethinking of the documentation and the creation of all the contents from scratch. Then the creation of the manual starts from the visual content (images or videos), adding only a minimal textual information to strengthen the instruction. As an example, this authoring strategy is used by Dozuki, and by Fixit, a well-known application of Dozuki, which is a wiki-based site that teaches people how to fix almost anything.

But the goal of technical documentation is the *augmented reality* approach. It requires the rethinking of the documentation and the creation of all the contents from scratch, too. In this case the creation of the manual starts from the observation of reality, and the visual contents (3D animations, CAD models, 2D graphic signs) are anchored on the real scene. The authoring of this kind of manuals is even more complex due to the difficulties to create a scalable solution. For example, the creation of an augmented reality manual for a phone teardown has different issues respect to that for a car repair, about tracking methods, working volumes, displays usable. There is still not a well-established procedure or software for the authoring of augmented reality manuals.

It is very likely that augmented reality will be the approach that will be used in the future. However, it is also predictable that this kind of documentation will not be ready soon. The augmented image approach is a solution ready to be used, but still not so diffuse in the industry. In fact, there is not an authoring standard to follow, furthermore the jump from the traditional documentation is very high and net, so people should be adequately trained to accept and use this manual. We could reasonably hypothesize that in the next two years this kind of documentation will reach the industrial world. The augmented text approach is instead ready to use in the factories even now. In fact, all the contents are ready, they should only be organized to be displayed in a new way.

In augmented text manuals, authors can use existing text instruction as it is. On the contrary, in the augmented image approach the text serves only to integrate the visual content: then, a reduction of text instruction is needed. In the augmented reality approach, the text information must be reduced as much as possible, because text occludes the reality. Legibility of text in AR is one of the most discussed research questions in the literature [12–17].

According to the authors, the key strategy for a company that wants to create a digital documentation today, is the following: create an augmented text manual that is ready to use now, ensures backward compatibility and satisfies the need of companies for paper manuals; but the creation would occur in a smart way, so that the content could be used as a starting point for the creation of the future manual with the augmented image or augmented reality approach. This is possible using XML-based standards as DITA (Darwin Information Typing Architecture) or oManual. They allow to insert special tags for the visual content, for example to add contents to show only in Augmented Reality.

In the following paragraph, we described our strategy to improve readability of text in textual instructions, using the Controlled Natural Languages and their rules. Then, we propose a method to analyze instructions taken from existing traditional manuals and convert them in a visual mode, reducing text. In this way, we offer a method to improve existing technical documentation, and to lay the groundwork for future visual manuals.

2.2 Improvement of text readability with Controlled Natural Languages

An objective method to improve readability of text in instructions is the use of Controlled Natural Languages (CNL) or simply controlled languages.

Kittredge [18] defined a controlled language (CL) as a restricted version of a natural language which has been engineered to meet a special purpose, most often that of writing technical documentation for non-native speakers of the document language. A typical CL uses a well-defined subset of a language’s grammar and lexicon, but adds the terminology needed in a technical domain.

The main advantages of Controlled Natural Languages are the following [18]:

- Improve communication among humans
- Improve translation
- Provide natural and intuitive representation for formal notations

These advantages justify the use of CNL for the creation of new digital manuals. Even if CNL exist from the 1930s and emerged also in the industrial environments, they are still less used for technical documentation. Many big companies (e.g., Kodak, Caterpillar, IBM, GM, etc.) tried to develop an own CNL, but after a few years they abandoned the development. Kamprath et al. [19], based on the experience made in Caterpillar, described the main issues for the development of a large-scale implementation of CNL:

1. Authoring: CNL and authoring should be developed simultaneously.
2. Vocabulary: the CNL domain is too complex for lexicographers to anticipate all the ways authors use words.
3. Translation: the requirement for accurate machine translation is a driving force in representing semantic ambiguity during CNL terminology development.
4. Semantics: adherence to CNL principles by authors is variable and sometimes difficult to enforce. It is possible for authors to write CNL-approved sentences which are syntactically correct, but semantically incorrect or incomprehensible.
5. People: qualified people to do terminology work are difficult to find.

The new industrial approaches to the creation of technical documentation suggested by Industry 4.0, together to the development of new software tools for authoring, give now the possibility to overcome these issues and encourage the use of CNL in the industrial world. However, there are still not standards to follow, so we made a review of all existing CNL to choose the one to be used in our approach.

Kuhn provided a detailed survey of CNL. Every language has some properties, related to the goal (e.g. T=Translation), the origin (e.g. I=Industry), the use (e.g. W=language intended to be written). To construct a principled classification scheme for such properties, they condensed them to four dimensions that are almost independent of each other:

- Precision: the degree to which the meaning of a text in a certain language can be directly retrieved from its textual form.
- Expressiveness: the range of propositions that a certain language can express.
- Naturalness: how close the language is to a natural language in terms of readability and understandability to speakers of the given natural language.
- Simplicity: the effort needed to fully implement the syntax and the semantics of the language in a mathematical model, such as a computer program.

These dimensions create the PENS classification, where each parameter have a ranking from 1 to 5. For example, for basic English it is $P^2E^5N^5S^1$.

For the choice of the CNL to be used in our model, we considered the property I, that means "language originated from Industry". Considering all the languages with this property, the average PENS value is P=2.3, E=4.3, N=4.7, S=1.4. Then we considered all the language with the PENS value closer to the average, that is $P^2E^5N^5S^1$. Many languages belong to this PENS class; among them, we considered those with the following properties:

- C, goal is comprehensibility.
- T, goal is translation.
- W, language intended to be written.
- D, language designed for a specific narrow domain: Pool [20] found that restrictive CNL were more successful than general CNL.
- I, language originated from industry.

Among all the languages with these properties, the one still in use is ASD Simplified Technical English. It is a CNL originated from the aerospace industry, and is used to improve the readability and comprehensibility of technical documentation [21]. ASD-STE is based on English with restrictions expressed in about 60 general rules. These rules restrict the language on the lexical level, on the syntactic level, as well as on the semantic level.

2.3 Use of graphic symbols

Most of technical instructions consist of tasks to be accomplished by the operator. Then most of the verbs used in technical documentations are action verbs. The method proposed in this work, aim to reduce the amount of text in a technical instruction, replacing the action verbs with graphic symbols.

To isolate action verbs, we considered verbs in the imperative tense and the verbs in the progressive tense. Progressive tense in not approved by STE, which only allows commands in the imperative tense, nevertheless it is common to use this tense to express the way an action should be accomplished (e.g. remove the component by pulling it). We discarded phrasal verbs (e.g. to get, to take, to make), as we could not verify which was the actual action commanded.

According to STE technical documentation provides two kinds of statement: instructions, and descriptions. Descriptive writing provides information, not commands, but commands may strongly rely on descriptions (e.g. a determined condition is required to perform an action). Descriptive verbs referring to an object, tool or component were generally in the present tense third person singular, which was then excluded.

However, the number of possible action verbs used in technical documentation is very high. The association of a graphic symbol to all action verbs increase difficulties both in the authoring and in the execution phase. We then defined two classes of action verbs:

1. Low-level verbs: action verbs to replace with graphic symbols;
2. High-level verbs: action verbs to not replace with graphic symbols.

A possible way to distinguish verbs is based on the familiarity of the system that we are going to define. For a new user, the familiarity of an interactive system measures the correlation between the user's existing knowledge and the knowledge required for effective interaction. For example, when word processors were originally introduced, an analogy between the word processor and a typewriter were intended to make the new technology more immediately accessible to those who had little experience with the former and quite a bit of experience with the latter. According to the authors, the same approach should be used in the transition from paper manual to augmented- manuals. Familiarity is related to guessability [22] and affordance [23], [24] criteria. Wobbrock et al. [25] defined guessability in symbolic input as: "*That quality of symbols which allows a user to access intended* *referents via those symbols despite a lack of knowledge of those symbols."* Similarly, *"there is affordance when the perceivable intrinsic properties of any object instigate the appropriate actions upon it, that is, the appearance of the object stimulates a familiarity with its behavior."* [26]

Considering the research objective of this work, we made the following remark: action verbs that entail a movement with just one possible degree of freedom and just one possible direction, are usually associated to objects with high affordance (e.g. "open a door"), and the associated graphic symbol would have a high guessability. Therefore, we considered this kind of verbs as low-level. For example, the verb "tighten" is usually associated to a threaded element, whose affordance is high.

A verb entailing a movement with two or more possible degrees of freedom, it is likely to be associated to objects with low affordance. For example, the verb "move" associated to an object, is not enough to specify the task to accomplish, because the object can be moved in different ways. Therefore, we considered this kind of verbs as high-level.

To get an exhaustive list of action verbs, we scanned all the iFixit repair guides in the category "Car and Truck". We collected all the verbs present in the guides. Then we put together all the not-STE verbs with the correspondent STE verbs suggested by the practice, adding the correspondent occurrences. Finally, we ranked them in terms of occurrences in the guides.

We examined the verbs with six or more occurrences and isolated those that we considered low-level. We made a distinction for the verb "turn": the verb, as it is, conveys an action with one degree of freedom, but two possible directions (clockwise and counterclockwise), and then it would be high-level. Therefore, we specified also the direction to make the verb low-level.

For each selected action, we also considered its opposite term, even in the case it was not among the most frequent verbs (e.g. "close"). This is because instructions on iFixit generally provide methods to perform disassembly and maintenance, and rarely give information about the re-assemble phase, which may also need to be considered in our case.

The complete list of low-level verbs is reported in Table 1:

Table 1: list of STE approved verbs considered as low-level and their frequency in iFixit.

STE approved verbs	STE unapproved verbs with same meaning	% iFixit
TIGHTEN		1.07%
LOOSEN	unscrew	1.04%
EXAMINE	inspect, test, check	1.77%
LIFT	raise	0.78%
PUSH	force, press	1.04%
PULL	draw	2.39%
TURN CLOCKWISE TURN COUNTERCLOCKWISE	spin, crank, orient, rotate, thread	1,62%
FILL	prime, refill	0.26%
DRAIN		0.64%
CLEAN	wipe, clear, wash	0.91%
CLOSE		0.19%
OPEN	crack	1.14%
CUT	trim, clip	0.16%

Below we reported examples of verbs taken from "2000-2005 Audi A4 Headlight Replacement" in the iFixit repair guide:

- Not-action verb: "The cabling *comes in* through the high beam cover, and can be a bit tricky to disconnect", step 6.
- High-level: "*Reach under* the cabling and feel around for a latch", step 6.
- Low-level not-STE: "*Unscrew* the hidden screw through the hole to the right of the assembly", step 5.
- Low-level STE: "*Pull* the latch upwards and *pull* relatively hard on the plug", step 6.

After having discussed about the opportunity to use STE and graphic symbols, in the next lines we summarize our strategy to improve readability and reduce text in visual technical documentation. This approach can be used as basis to create, with low effort, augmented image and augmented reality versions of the same manual. The method is described in the following steps (using STE writing rules) and formalized in Fig. 2:

1. Read and isolate each instruction.
2. Do a check for STE rules.
3. Isolate all the action verbs in the instruction.
4. Make sure that the action verbs are STE approved.
5. For STE verbs of the low-level class, replace the action verb with the related graphic symbol.

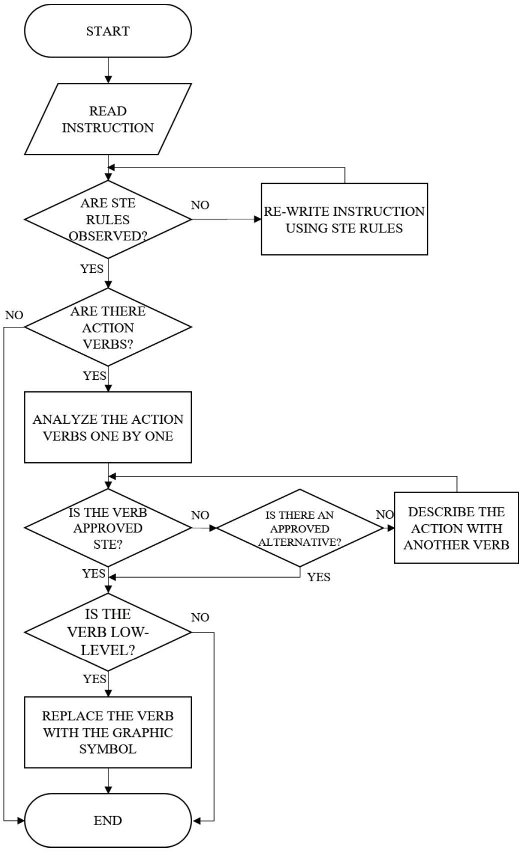

Fig. 2. Workflow of the proposed method for text reduction and simplification in technical documentation.

3. Conclusion

In this work, we addressed the issue of the authoring of digital technical documentation. The results provided are limited to technical domains. We proposed an optimized workflow to reduce text in technical documentation. For the residual text instructions, we proposed the use of ASD Simplified Technical English (STE) to improve readability. This method can be the starting point for the creation of an augmented-image or augmented-reality version of the manual.

The method is based on the analysis of the action verbs present in the instructions. We defined two classes of verbs:

- low-level action verbs, for which we suggest to replace the instruction with a graphic sign;
- high-level action verbs, for which we suggest to convert the instruction in a STE approved form.

We examined the iFixit repair guides in the category “Car and Truck”. We analyzed 7178 verbs:

- 57.6% of them were approved STE verbs, whereas 36.2% were not approved but there is an alternative verb suggested; there were also 6.2% of verbs that cannot be replaced with a verb, but with a noun (e.g. need, work).

- 87.4% of them were action verbs
- Among the action verbs approved STE, 11.4% were low-level.

The proposed method is a scalable solution that can be easily applied to existing manuals. However, it is only a first approach to reduce text. Great improvements can be done: for example, we found a subset of verbs that, according to the authors, could be replaced with symbols even if they are not low-level verbs: *move, assemble, disassemble, install, remove, replace, hold*. Considering also these verbs, we could convert in symbols, 27.4% of the analyzed manual.

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