



A Management Brief

Hybrid Machine Translation:

Raising the Price/Performance Bar for Translation Operations Managers

The hybrid machine translation (HMT) system is a powerful tool for assisting linguists, translators, and intelligence analysts in achieving greater productivity and high-quality results in a timely and cost-effective manner. Moreover, HMT systems offer agency managers significant economic value in both initial costs and long-term operating expense.

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Management's Dilemma

In an era of heightened security awareness, the need to intercept and interpret foreign language transmissions is paramount. Working under high threat levels, translation and intelligence operations managers must cope with a three-headed challenge: data overload, a scarcity of skilled linguists and translators, and constrained budgets.

Among government, military, and commercial markets alike, intelligence gathering on a global scale has dramatically increased the need for high-quality, accurate, and timely translations. Coincidentally, the volume of data to be translated, whether from print media, phone calls, text messages, e-mails, websites, or radio and television broadcasts, has multiplied several times over.

Even so, translation and intelligence operations managers cannot simply hire more linguists or translators. Skilled linguists and translators are in demand and the pool of experienced candidates is limited. Moreover, retaining the current staff and keeping them motivated is a challenge in the face of data overload, time pressures, and overall job satisfaction.

Machine translation (MT) provides a solution (presentations, web pages, etc.) from one language to another. MT is designed to support and assist anyone involved in translating one human language to another, whether these individuals serve as skilled translators in multinational forums like the United Nations or in highly specialized linguist and analyst roles in the defense intelligence field.

For practical purposes, MT performance still involves human translators and linguists to refine the output. Think of MT applications as a front-end of the translation workflow process for tasks to be performed on the high volume of incoming materials, as in triage or initial screening, and as tools

for specific tasking downstream for specific information tasks, such as foreign name normalization or automated entity extraction.

By planning and implementing the right mix of MT and human translators, translation and intelligence operations business managers can realize a streamlining of business processes, productivity enhancements, and a bigger payoff for the investment.

The key questions are: How good are MT translations? How do we know? What is the right mix of MT with human translators and linguists? What is the payoff?

Measuring MT Performance

MT systems have been in development for decades. Computing technology has advanced in speed and power and software has been developed to understand and process human languages using different methodologies. From a variety of data sources, MT can now translate phrases in context and interpret meanings and inferences in dozens of languages, including dialects.

MT is at a point where many different languages can be translated to and from English with a very high degree of accuracy and fluency. This is not to suggest that machines will replace human translators. Rather, MT can complement human translators and linguists in performing high-volume, complex translations efficiently and cost-effectively, especially in mission-critical applications.

There are three key translation parameters that managers can use to assess the quality and accuracy of MT outputs: fluency, informativeness, and adequacy.

Fluency determines how readable the translated text is, based on the order of words and the grammar of the target language. Fluency determines whether a

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person is able to read the translated text smoothly and easily.

Informativeness means how accurately the information is being conveyed in the translation, including a score on the quantity of information being transferred from the source to the target language.

Adequacy refers to the quality of the information that was transferred from the source to the target language.

Translating Human Languages

Human language translation, in its simplest definition, involves:

- Decoding the meaning of the source text; and
- Re-encoding this meaning into the target language.

A skilled translator determines the meaning of the source text in its entirety. This means that the translator interprets and analyzes all the features of the source language text by applying in-depth knowledge of elements such as the grammar, semantics, syntax, and idioms, as well as the culture of its speakers. At the same time, the translator needs an equivalent in-depth knowledge to re-encode the meaning in the target language.

The question is: How do you program a computer to “understand” a text just as a person does, and also to “create” a new text in the target language that “sounds” as if it has been written by a person?

How MT Translates Human Language

MT involves the use of computer software to translate one human language into another, such as Arabic to English or English to Korean.

MT considers the grammatical structure of each language and uses contextual rules to select among multiple meanings in order to transfer sentences from the source language (to be translated) into the target language (translated).

Foreign language translation can be challenging, even for a skilled linguist. The sheer volume of multilingual content, especially in some environments, exacerbates the problem. Performing the same translations with the aid of MT increases the accuracy and speed of translating text and identifying key points of interest. MT provides an opportunity for users to offload their bulk processing tasks to the software thereby allowing themselves to focus their efforts and skills on the high-value information. An example would be to use MT, at a minimum, as a triage tool during the initial phase of content screening of hundreds or thousands of documents to determine which ones contain time-sensitive information and which ones can be queued for later review.

To accomplish this, MT is typically implemented using two methodologies: rule-based methods and statistical methods.

Rule-based Machine Translation

Rule-based machine translation (RBMT) uses linguistic rules. This means that words and phrases will be translated based on an in-depth knowledge of the language; the most suitable words of the target language will replace the ones in the source language. RBMT provides more of a human element to the translation because the rules are user-defined based on an understanding of the target language.

Generally, rule-based methods parse a text, usually creating an intermediary, symbolic representation from which the text in the target language is generated. These methods require extensive vocabulary along with word meanings, how words are formed, and how words are arranged to create meaning, all governed by large sets of rules.

RBMT programs are highly advanced and allow a native speaker of the target language to comprehend what is written by the native speaker of the source language. The advantage of rule-based translation is that it

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accommodates fairly abstract text and the “informativeness” of the translation is high for coverage of a greater number of domains and types of texts.

Statistical Machine Translation

Statistical MT (SMT) systems use examples and apply statistical techniques to a large body of language data to perform translations. SMT systems learn from text alignment rather than in-depth grammatical knowledge as with RBMT systems.

The SMT system is a special form of a corpus-based MT system that extracts abstract information out of corpora and weighs all the information according to a mathematical model.

SMT relies on very fast computing to annotate the corpora and prepare the data for translation while drawing on many examples from which to learn.

The main requirement is that SMT needs a certain volume of data to be effective. An example of a large body of language data is the Canadian Hansard corpus, the English-French record of the Canadian Parliament, from which to extract examples. With such a database, SMT can produce translations with high grades of fluency as long as the sample sentences are of the same domain and similar type as the sentences in the training data.

Hybrid MT: The Best of Both Worlds

The Hybrid MT (HMT) solution combines the strengths of both rule-based and statistical systems. The term “hybrid” in this context can be understood several ways.

From a technology perspective, HMT combines the best features and capabilities of both RBMT and SMT platforms. Here, $HMT = RBMT + SMT$.

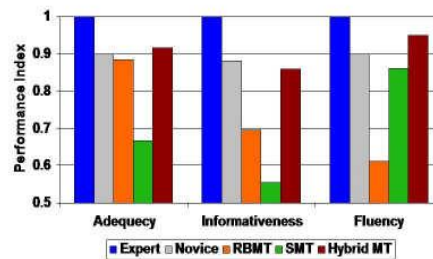
If one considers the language aspect, then HMT combines the highest level of translation attributes that approach what a translator can deliver. As such, $HMT =$

Fluency + Informativeness + Adequacy. Consequently, HMT provides significant advances to automated translation of large volumes of speech and text data compiled from a variety of sources.

The results of comparative performance among RBMT, SMT, and HMT system tests, based on those three criteria, are shown in Exhibit 1.

More significantly, the chart also shows how HMT performance measures against the capabilities of human translators, both expert and novice.

HMT Comparative Performance



The results show that the HMT system performance compares closely to a novice human translator and in all three performance categories scores higher than either RBMT and SMT systems. RBMT systems score higher than the SMT system in the areas of adequacy and informativeness. On the other hand, SMT systems score better than RBMT in the fluency of translations.

With this type of performance, HMT can address and streamline the tasks that linguists and translators perform. HMT systems can assist and support linguists and translators in translating and interpreting large volumes of information. This is done in a very efficient, timely, and cost-effective manner that is better than if manual translation alone were used, and at higher performance levels than standalone RBMT

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or SMT systems.

AppTek HMT Breakthrough

AppTek’s development of the HMT solution is a breakthrough because it provides a full integration of two complete MT methodologies

(a.k.a. systems), rather than simply taking a shortcut approach by adding some rules to the statistical system or adding a minor statistical module to the rule-based engine. Consequently, AppTek’s HMT provides the optimal features of both MT approaches.

AppTek is the only provider of human language technology (HLT) to have successfully proven the performance of this HMT platform. In independent tests, the AppTek HMT systems scored very well two years in a row in the National Institute of Standards & Technology (NIST) MT evaluations. The HMT approach performed best in Noisy Data in the 2006/2007 evaluation, and in the Top 3 overall in the recent 2008 evaluation¹.

Figure 1 compares the performance of AppTek’s HMT system with a major third party SMT system on the informativeness of sample translations of Arabic to English text from publicly available general news and military sources. AppTek’s HMT produced higher levels of informativeness than the third party SMT system.

The Business Case for Hybrid MT

Demonstrating the performance advancements of HMT systems over conventional translation methods is very important for translation services and intelligence operations managers.

But the question these managers want their vendors to answer is: “Where is the payoff?”

¹ <http://www.nist.gov/speech/tests/mt/2008/doc/>

AppTek’s HMT is the answer in two important aspects: performance and value.

With improved translations in fluency, informativeness, and adequacy, the amount of time that a trained linguist, translator, or intelligence analyst must spend editing and polishing the translated output can be significantly reduced. Their productivity goes up, and they deliver accurate results in a more timely and cost-effective manner. A higher level of job satisfaction is the result of producing high-quality results while reducing the tedious efforts to find high-value pieces of information amid a morass of incoming data.

A relative cost comparison of today’s standard MT platforms, either RBMT or SMT, with HMT is shown in Figure 2.

Figure 2. Standard MT vs. HMT Costs

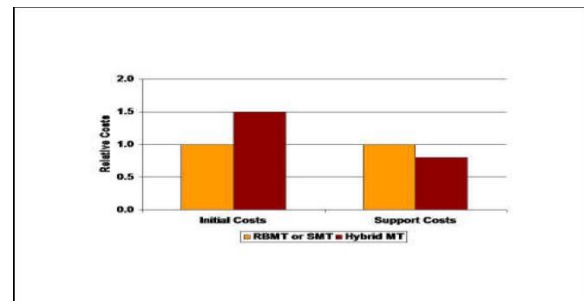


Figure 1. Source: AppTek, Industry Reports

The configurations assume one server with five concurrent users with translation software for one language and its translations in one direction. For this comparison, a standard MT relative price is the average of RBMT and SMT systems that are on the market today.

On an initial cost basis, the HMT integrated system delivers more than twice the performance at roughly 1.5 times the average cost of either RBMT or SMT system, but less than the approximate 2.0 times the cost if an organization were to operate both an RBMT and SMT system in parallel.

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Since AppTek’s HMT platform is part of an integrated suite of HLT applications, the level of software and system support in subsequent is projected at 75–80% of the levels needed to support discrete MT platforms that use third party software to build out applications.

Exhibit 3 shows the productivity improvements that can be realized over time as linguists, translators, and analysts gain experience in working with HMT systems. The chart projects that even with staffing levels remaining constant and with relatively low HMT operating expenses growing modestly over a 5-year period, operations managers could expect to realize productivity improvements on the order of 50% over present levels.

Conclusion

AppTek’s Hybrid MT system is the state-of-the art in machine translation that delivers significant price/performance gains over other available MT platforms.

AppTek HMT provides users with greater productivity and more accurate translations in a timely and cost-effective manner while promising a bigger “bang for the buck” for translation operations managers.

Figure 3 HMT Productivity Gains

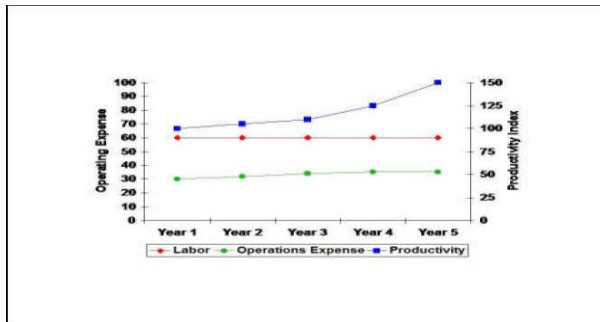


Figure 2. AppTek Estimates

Another important intangible benefit for business managers is that their group or organization becomes an even more valuable contributor of timely and high-quality intelligence and analyses that support the policy and strategic decision makers within their agency.

Appendix I provides a reference checklist to help translation operations managers specify HMT components in upcoming RFIs and RFQs.

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Appendix

Table 1: Machine Translation output of AppTek’s Hybrid Machine Translation in comparison to a state-of-the-art third party Statistical Machine Translation

News & General	AppTek HMT	Third Party SMT	Remarks
مشر فيدع وللمصالح تويتجاهل مساع يباعد هع نالسلطة	Musharraf calls for reconciliation and ignores the efforts his expulsion from the authority.	Musharraf calls for reconciliation efforts and ignores the removal from power.	For fluency the SMT removed the pronoun and created ambiguity about who is being removed.
عملي قبالقل بللطالبان يوالمشهداني بعما نالجر اءفحوص	Process in the heart to Jalal Talabani and Al Mashhdani in Amman for examinations.	The heart of Amman, al-Mashhadani, Talabani and for tests.	The correct translation is a heart operation in Amman for Talabani and tests for Mashhadani.
ووق عالنفجي رحوال يساع النامن قوالنص فصباح ابالتوقي تالمحلي. وه وموع دوصو لالمراجعي نال يدانر الجوازات, واسف رع ناحترا فخم سسيارا تمدني قوالحا قاضرا رمادي قبالمبان يوالمحا لالتجاري المجاورة	The explosion occurred about eight thirty a.m. local time, an arrival date of auditors to the circle passports, and resulted in the burning five civil cars and causing material damages to the buildings and neighboring shops.	The explosion occurred about eight o'clock in the morning local time, when the arrival of auditors to the Passport Service, and resulted in the burning of five civilian cars and causing material damage to buildings and shops nearby.	The correct translation of the time is eight thirty (8:30 am) not 8.
وذك الرمصد را نشاحن قمفخ قمن طرا ن(كيا) كان تمركون قبالقرب م نمرا بللسيارا تتاب عدانرة جوازا نالاعظمي الواقع قفي شار عالمغر بانفجر تموقع 12 ققتي لامدني او عشري نجرىحا	The source said a truck bomb of the type (a) was parked near the garage for the cars belonging to the service passports-in the street of morocco exploded killing 12 civilians and twenty injured.	The source said that a truck bomb aircraft (Kia) was near Marconi garage for cars continued to circle passports Alaazemih located in the street exploded Morocco signed 12 civilians were killed and twenty injured.	All words in red are absolutely wrong translations. It is a truck not an aircraft. It is a parking garage not Marconi garage. It is Morocco street not Morocco

Source: AppTek; Industry reports

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1. RFQ/RFP Components for HMT Implementation Contract

Performance Requirements

- Capable of providing a Commercial off the Shelf (COTS) English-to-Available Foreign Language and Available Foreign Language-to-English automated document translation system
- The capability must:
 - Support document translation for Microsoft Office products (Word, PowerPoint),
 - Operate within a Windows XP/Vista environment,
 - Perform as a server-based chat application.
- The input will be in either English text or Foreign Language text.
- The output will consist of either English text or Foreign Language text in the original format.
- Languages of interest are:
 - Spanish
 - Portuguese
 - French
 - Arabic
 - Bahasa
 - Dari
 - Dutch
 - Egyptian Dialect
 - English
 - Farsi/Persian
 - German
 - Hebrew
 - Iraqi Dialect
 - Korean Pashto
 - Polish
 - Russian
 - Simplified Chinese
 - Tagalog
 - Traditional Chinese
 - Turkish
 - Ukrainian
 - Urdu
 - Italian
 - Japanese
- Provider should have demonstrable strong performance results in HMT testing by an official government testing and evaluation organization.
- System user must be able to choose between rule-based only, statistical-only, or hybrid machine translation.
- The system must provide special domain dictionaries for specific vocabularies in:
 - Military
 - Special Operations
 - Mechanical
 - Political and Diplomatic
 - Nuclear
 - Chemical
 - Aviation
 - Computer and Technology
 - Medical
 - Business and Economics
 - Law Enforcement
 - Drug Terms
- The system must provide a Dictionary Maintenance Utility that allows for easy updating/customization of any or all of the dictionaries.
- The system must be available on the GSA schedule.



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About AppTek

Applications Technology, Inc. (AppTek), headquartered in McLean, Virginia, is a U.S.-based company that specializes in software development and application of human language technology.

Founded in 1990, AppTek has a high-caliber, world-renown staff of linguists, computer scientists, and software specialists that produce some of the most advanced and proven HLT products in the world. The company maintains staff in eight countries outside of the United States.

AppTek's portfolio of applications includes:

- MT for 23 different language pairs,
- Multilingual information retrieval with query and topic search capabilities,
- Name-finding applications, and
- Integrated suites that provide automatic speech recognition (ASR) and MT for specialized applications such as broadcast news.
- APIs and SDKs are also available for third party integration and development.

AppTek's patent-pending products are used extensively by U.S. and foreign governments, defense and intelligence agencies, and perform critical tasks of translating languages and deciphering volumes of data.

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