

Statistical Machine Translation

Taro Watanabe

Universal Communication Research Institute
National Institute of Information and Communications
Technology (NICT)

HIT Summer School
August, 2011

News in Chinese

铁道部部长盛光祖道歉 开展两个月安全生产大检查

据铁道部网站消息，7月24日21时，铁道部召开全路运输安全紧急电视电话会议。铁道部党组书记、部长盛光祖代表铁道部，对“7·23”甬温线特别重大铁路交通事故遇难者表示沉痛哀悼，对受伤人员和伤亡人员家属表示深切慰问，对广大旅客表示深深的歉意。盛光祖要求，从现在开始到9月底，开展两个月的安全生产大检查活动。

据最新消息，截至25日23时许，“7·23”甬温线特别重大铁路交通事故已造成39人死亡，其中初步确定身份的有38人。

盛光祖在电话会议上指出，目前，摆在全路党政工团各级组织和广大干部职工面前的首要任务，就是认真开展安全大检查活动，全面排查和消除安全隐患，坚决防止发生新的严重事故，迅速稳定运输安全局面，并提出以下5项要求：

第一，各级干部迅速深入运输一线实行安全包保。各级干部要把迅速稳定安全局面作为当前最重要的任务，深入到运输一线和安全生产的重点部位，对安全工作进行全方位的包保。包保干部要面对面地向职工传达中央领导同志的重要指示，讲清“7·23”事故的深刻教训，紧密结合本单位安全生产存在的问题，组织职工反思查找问题根源，吸取事故教训，引导广大职工认清安全生产的极端重要性，认清当前铁路安全生产的严峻形势，强化安全是铁路运输生命线的意识，切实增强确保安全的责任感、紧迫感。在包保中，要实行严格管理、严格要求，尤其要严格两纪管理，同时要加强思想引导工作，增强广大职工遵章守纪的自觉性。

http://news.xinhuanet.com/politics/2011-07/26/c_121719498.htm

Google Translate

Minister of Railways Sheng Guangzu apologize to carry out safety inspections for two months

According to the Ministry of Railways website news, at 21:00 on July 24, all held in the Ministry of Railways Road transport safety emergency video conference. Party secretary of the Ministry of Railways, Minister Sheng Guangzu on behalf of the Ministry of Railways, the "7.23" Yongwen particularly important railway line accident victims and express our deep condolences to the families of injured and casualties expressed deep sympathy for the majority of visitors indicated that deep sorry. Sheng Guangzu requirements, from now until the end of September, two months to carry out safety inspection activities.

According to the latest news at 25, 23 am, "7.23" Yongwen major railway line in particular has resulted in 39 traffic deaths, to determine the identity of the initial 38 people.

Sheng Guangzu on the conference call that, at present, put in the whole railway organizations at all levels of party and government work group and the cadres and workers in front of the primary task is to conscientiously carry out safety inspection activities, a comprehensive investigation and elimination of security risks, resolutely prevent the occurrence of serious new accidents, rapid stabilization of the transport safety situation, and made the following five requirements:

First, the rapid in-depth transportation front-line cadres at all levels to implement security package protection. Cadres at all levels should quickly stabilize the security situation as the most important task, deep into the transport line and safety of key positions on the all-round security package protection. Package security cadres of workers to communicate face to face to the central leaders of the important instructions made clear that "7.23" incident of the profound lessons in close connection with the unit safety problems, reflect on the organization of workers find the source of the problem, draw lessons from the accident, and guide the workers understand the extreme importance of safety, understand the current grim situation of rail safety, rail transport is the lifeline to strengthen security awareness, and enhance the sense of responsibility to ensure security, a sense of urgency. Paul in the package, a strict management and strict requirements, in particular, to strictly two discipline management, and to strengthen the ideological guidance, and enhance the consciousness of the masses of workers disciplined.

Bilingual Data

- 1.上海浦东开发与法制建设同步
- 2.新华社上海二月十日电（记者谢金虎、张持坚）
- 3.上海浦东近年来颁布实行了涉及经济、贸易、建设、规划、科技、文教等领域的七十一件法规性文件，确保了浦东开发的有序进行。
- 4.浦东开发开放是一项振兴上海，建设现代化经济、贸易、金融中心的跨世纪工程，因此大量出现的是以前不曾遇到过的新情况、新问题。
- 5.对此，浦东不是简单的采取“干一段时间，等积累了经验以后再制定法规条例”的做法，而是借鉴发达国家和深圳等特区的经验教训，聘请国内外有关专家学者，积极、及时地制定和推出法规性文件，使这些经济活动一出现就被纳入法制轨道。
- 6.去年初浦东新区诞生的中国第一家医疗机构药品采购服务中心，正因为一开始就比较规范，运转至今，成交药品一亿多元，没有发现一例回扣。

- 1.The development of Shanghai's Pudong is in step with the establishment of its legal system
- 2.Xinhua News Agency, Shanghai, February 10, by wire (reporters Jinhu Xie and Chijian Zhang)
- 3.In recent years Shanghai's Pudong has promulgated and implemented 71 regulatory documents relating to areas such as economics, trade, construction, planning, science and technology, culture and education, etc., ensuring the orderly advancement of Pudong's development.
- 4.Pudong's development and opening up is a century-spanning undertaking for vigorously promoting Shanghai and constructing a modern economic, trade, and financial center. Because of this, new situations and new questions that have not been encountered before are emerging in great numbers.
- 5.In response to this, Pudong is not simply adopting an approach of "work for a short time and then draw up laws and regulations only after waiting until experience has been accumulated." Instead, Pudong is taking advantage of the lessons from experience of developed countries and special regions such as Shenzhen by hiring appropriate domestic and foreign specialists and scholars, by actively and promptly formulating and issuing regulatory documents, and by ensuring that these economic activities are incorporated into the sphere of influence of the legal system as soon as they appear.
- 6.Precisely because as soon as it opened it was relatively standardized, China's first drug purchase service center for medical treatment institutions, which came into being at the beginning of last year in the Pudong new region, in operating up to now, has concluded transactions for drugs of over 100 million yuan and hasn't had one case of kickback.

(part of LDC2007T02, English translation of Chinese treebank)

Guess Translation

- 1.上海浦东开发与法制建设同步
- 2.新华社上海二月十日电（记者谢金虎、张持坚）
- 3.上海浦东近年来颁布实行了涉及经济、贸易、建设、规划、科技、文教等领域的七十一件法规性文件，确保了浦东开发的有序进行。
- 4.浦东开发开放是一项振兴上海，建设现代化经济、贸易、金融中心的跨世纪工程，因此大量出现的是以前不曾遇到过的新情况、新问题。
- 5.对此，浦东不是简单的采取“干一段时间，等积累了经验以后再制定法规条例”的做法，而是借鉴发达国家和深圳等特区的经验教训，聘请国内外有关专家学者，积极、及时地制定和推出法规性文件，使这些经济活动一出现就被纳入法制轨道。
- 6.去年初浦东新区诞生的中国第一家医疗机构药品采购服务中心，正因为一开始就比较规范，运转至今，成交药品一亿多元，没有发现一例回扣。

- 1.The development of Shanghai's Pudong is in step with the establishment of its legal system
- 2.Xinhua News Agency, Shanghai, February 10, by wire (reporters Jinhu Xie and Chijian Zhang)
- 3.In recent years Shanghai's Pudong has promulgated and implemented 71 regulatory documents relating to areas such as economics, trade, construction, planning, science and technology, culture and education, etc., ensuring the orderly advancement of Pudong's development.
- 4.Pudong's development and opening up is a century-spanning undertaking for vigorously promoting Shanghai and constructing a modern economic, trade, and financial center. Because of this, new situations and new questions that have not been encountered before are emerging in great numbers.
- 5.In response to this, Pudong is not simply adopting an approach of "work for a short time and then draw up laws and regulations only after waiting until experience has been accumulated." Instead, Pudong is taking advantage of the lessons from experience of developed countries and special regions such as Shenzhen by hiring appropriate domestic and foreign specialists and scholars, by actively and promptly formulating and issuing regulatory documents, and by ensuring that these economic activities are incorporated into the sphere of influence of the legal system as soon as they appear.
- 6.Precisely because as soon as it opened it was relatively standardized, China's first drug purchase service center for medical treatment institutions, which came into being at the beginning of last year in the Pudong new region, in operating up to now, has concluded transactions for drugs of over 100 million yuan and hasn't had one case of kickback.

(part of LDC2007T02, English translation of Chinese treebank)

Guess Translation

- 1.上海浦东开发与法制建设同步
- 2.新华社上海二月十日电（记者谢金虎、张持坚）
- 3.上海浦东近年来颁布实行了涉及经济、贸易、建设、规划、科技、文教等领域的七十一件法规性文件，确保了浦东开发的有序进行。
- 4.浦东开发开放是一项振兴上海，建设现代化经济、贸易、金融中心的跨世纪工程，因此大量出现的是以前不曾遇到过的新情况、新问题。
- 5.对此，浦东不是简单的采取“干一段时间，等积累了经验以后再制定法规条例”的做法，而是借鉴发达国家和深圳等特区的经验教训，聘请国内外有关专家学者，积极、及时地制定和推出法规性文件，使这些经济活动一出现就被纳入法制轨道。
- 6.去年初浦东新区诞生的中国第一家医疗机构药品采购服务中心，正因为一开始就比较规范，运转至今，成交药品一亿多元，没有发现一例回扣。

- 1.The development of Shanghai's Pudong is in step with the establishment of its legal system
- 2.Xinhua News Agency, Shanghai, February 10, by wire (reporters Jinhu Xie and Chijian Zhang)
- 3.In recent years Shanghai's Pudong has promulgated and implemented 71 regulatory documents relating to areas such as economics, trade, construction, planning, science and technology, culture and education, etc., ensuring the orderly advancement of Pudong's development.
- 4.Pudong's development and opening up is a century-spanning undertaking for vigorously promoting Shanghai and constructing a modern economic, trade, and financial center. Because of this, new situations and new questions that have not been encountered before are emerging in great numbers.
- 5.In response to this, Pudong is not simply adopting an approach of "work for a short time and then draw up laws and regulations only after waiting until experience has been accumulated." Instead, Pudong is taking advantage of the lessons from experience of developed countries and special regions such as Shenzhen by hiring appropriate domestic and foreign specialists and scholars, by actively and promptly formulating and issuing regulatory documents, and by ensuring that these economic activities are incorporated into the sphere of influence of the legal system as soon as they appear.
- 6.Precisely because as soon as it opened it was relatively standardized, China's first drug purchase service center for medical treatment institutions, which came into being at the beginning of last year in the Pudong new region, in operating up to now, has concluded transactions for drugs of over 100 million yuan and hasn't had one case of kickback.

(part of LDC2007T02, English translation of Chinese treebank)

Guess Translation

- 1.上海浦东开发与法制建设同步
- 2.新华社上海二月十日电（记者谢金虎、张持坚）
- 3.上海浦东近年来颁布实行了涉及经济、贸易、建设、规划、科技、文教等领域的七十一件法规性文件，确保了浦东开发的有序进行。
- 4.浦东开发开放是一项振兴上海，建设现代化经济、贸易、金融中心的跨世纪工程，因此大量出现的是以前不曾遇到过的新情况、新问题。
- 5.对此，浦东不是简单的采取“干一段时间，等积累了经验以后再制定法规条例”的做法，而是借鉴发达国家和深圳等特区的经验教训，聘请国内外有关专家学者，积极、及时地制定和推出法规性文件，使这些经济活动一出现就被纳入法制轨道。
- 6.去年初浦东新区诞生的中国第一家医疗机构药品采购服务中心，正因为一开始就比较规范，运转至今，成交药品一亿多元，没有发现一例回扣。

- 1.The development of Shanghai's Pudong is in step with the establishment of its legal system
- 2.Xinhua News Agency, Shanghai, February 10, by wire (reporters Jinhu Xie and Chijian Zhang)
- 3.In recent years Shanghai's Pudong has promulgated and implemented 71 regulatory documents relating to areas such as economics, trade, construction, planning, science and technology, culture and education, etc., ensuring the orderly advancement of Pudong's development.
- 4.Pudong's development and opening up is a century-spanning undertaking for vigorously promoting Shanghai and constructing a modern economic, trade, and financial center. Because of this, new situations and new questions that have not been encountered before are emerging in great numbers.
- 5.In response to this, Pudong is not simply adopting an approach of "work for a short time and then draw up laws and regulations only after waiting until experience has been accumulated." Instead, Pudong is taking advantage of the lessons from experience of developed countries and special regions such as Shenzhen by hiring appropriate domestic and foreign specialists and scholars, by actively and promptly formulating and issuing regulatory documents, and by ensuring that these economic activities are incorporated into the sphere of influence of the legal system as soon as they appear.
- 6.Precisely because as soon as it opened it was relatively standardized, China's first drug purchase service center for medical treatment institutions, which came into being at the beginning of last year in the Pudong new region, in operating up to now, has concluded transactions for drugs of over 100 million yuan and hasn't had one case of kickback.

(part of LDC2007T02, English translation of Chinese treebank)

Machine Translation

- We learn parameters from data assuming a “model”
- Remark: we dropped “statistical” since this view is applicable to any MT including rule-based MT

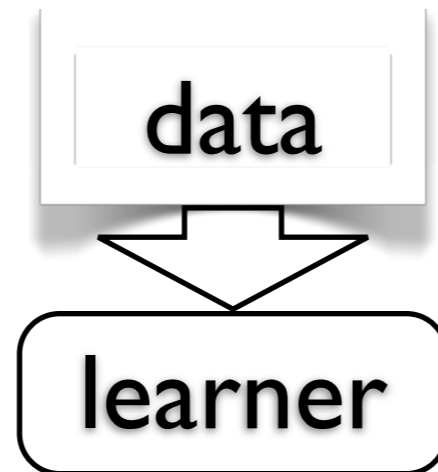
Machine Translation



data

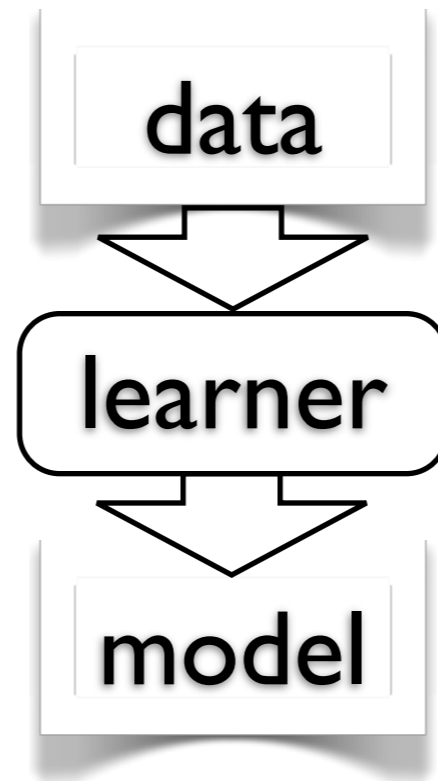
- We learn parameters from data assuming a “model”
- Remark: we dropped “statistical” since this view is applicable to any MT including rule-based MT

Machine Translation



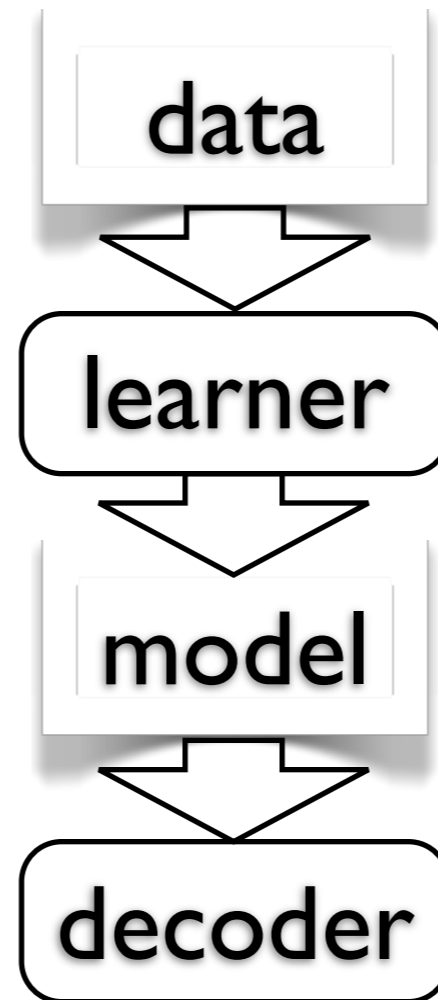
- We learn parameters from data assuming a “model”
- Remark: we dropped “statistical” since this view is applicable to any MT including rule-based MT

Machine Translation



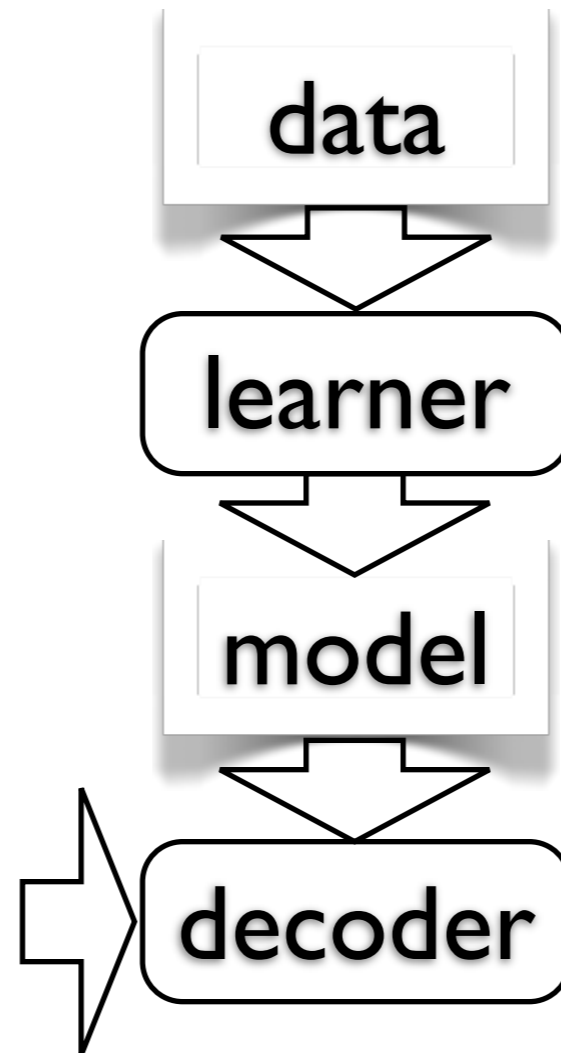
- We learn parameters from data assuming a “model”
- Remark: we dropped “statistical” since this view is applicable to any MT including rule-based MT

Machine Translation



- We learn parameters from data assuming a “model”
- Remark: we dropped “statistical” since this view is applicable to any MT including rule-based MT

Machine Translation

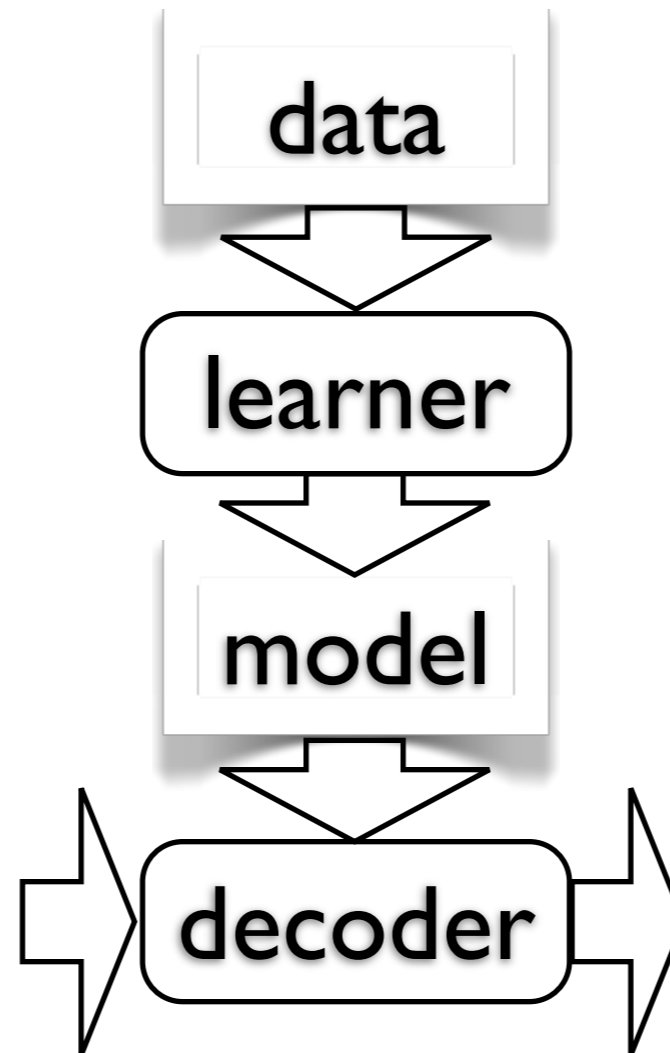


黑山头口岸联检部门将原来要二至三天办完的出入境手续改为一天办完。

- We learn parameters from data assuming a “model”
- Remark: we dropped “statistical” since this view is applicable to any MT including rule-based MT

Machine Translation

黑山头口岸联检部门将原来要二至三天办完的出入境手续改为一天办完。



The United Inspection Department of Heishantou Port has shortened the procedures for leaving and entering the territory from originally 2 - 3 days to 1 day.

- We learn parameters from data assuming a “model”
- Remark: we dropped “statistical” since this view is applicable to any MT including rule-based MT

Questions

- How to judge the correctness of translation?
- How to model the process of translation?
- How to learn the parameters (given data + model)?
- How to decode (given model + parameters + input sentence)?
- And, we do not cover, “how to collect data?”

Outline

- MT Evaluation
- Modeling, Training, Decoding
 - Word Alignment
 - Phrase-based Models
 - Tree-based Models

Outline

- **MT Evaluation**
- Modeling, Training, Decoding
 - Word Alignment
 - Phrase-based Models
 - Tree-based Models

Translation Evaluation

- How do you know translations are good or bad?
- Human judgement
 - Fluency/Adequacy, Human Translation Error Rate (H-TER), Ranking etc.
- Automatic measures: Bleu(Papineni et al., 2002), NIST(Doddington, 2002), Rouge(Lin and Och, 2004), Meteor(Banerjee and Lavie, 2005) , TER (Snover et al., 2006), RIBES(Isozaki et al, 2010) etc.
- Uses reference translations

Evaluation: ngram precision

Well , I 'd like to stay five nights beginning
October twenty-fifth to thirty .

- I 'd like to stay there for five nights , from October twenty fifth to the thirtieth .
- I want to stay for five nights , from October twenty fifth to the thirtieth .
- I 'd like to stay for five nights , from October twenty fifth to the thirtieth .
- I would like to reserve a room for five nights , from October twenty fifth to the thirtieth .

Evaluation: ngram precision

Well , I 'd like to stay five nights beginning
October twenty-fifth to thirty .

$$p_1 = \frac{11}{15}$$

- I 'd like to stay there for five nights , from October twenty fifth to the thirtieth .
- I want to stay for five nights , from October twenty fifth to the thirtieth .
- I 'd like to stay for five nights , from October twenty fifth to the thirtieth .
- I would like to reserve a room for five nights , from October twenty fifth to the thirtieth .

Evaluation: ngram precision

Well , I 'd like to stay five nights beginning
October twenty-fifth to thirty .

$$p_1 = \frac{11}{15} \quad p_2 = \frac{5}{14}$$

- I 'd like to stay there for five nights , from October twenty fifth to the thirtieth .
- I want to stay for five nights , from October twenty fifth to the thirtieth .
- I 'd like to stay for five nights , from October twenty fifth to the thirtieth .
- I would like to reserve a room for five nights , from October twenty fifth to the thirtieth .

Evaluation: ngram precision

Well , I 'd like to stay five nights beginning October twenty-fifth to thirty .

$$p_1 = \frac{11}{15}$$

$$p_2 = \frac{5}{14}$$

$$p_3 = \frac{3}{13}$$

- I 'd like to stay there for five nights , from October twenty fifth to the thirtieth .
- I want to stay for five nights , from October twenty fifth to the thirtieth .
- I 'd like to stay for five nights , from October twenty fifth to the thirtieth .
- I would like to reserve a room for five nights , from October twenty fifth to the thirtieth .

Evaluation: ngram precision

Well , I 'd like to stay five nights beginning October twenty-fifth to thirty .

$$p_1 = \frac{11}{15}$$

$$p_2 = \frac{5}{14}$$

$$p_3 = \frac{3}{13}$$

$$p_4 = \frac{2}{12}$$

- I 'd like to stay there for five nights , from October twenty fifth to the thirtieth .
- I want to stay for five nights , from October twenty fifth to the thirtieth .
- I 'd like to stay for five nights , from October twenty fifth to the thirtieth .
- I would like to reserve a room for five nights , from October twenty fifth to the thirtieth .

Evaluation: BLEU

$$\exp \left(\sum_{n=1}^N w_n \log p_n + \min\left(1 - \frac{r}{c}, 0\right) \right)$$

- Weighted combination of precision (Papineni et al., 2002)
- brevity penalty: penalize too short sentences
 - r = reference length, c = candidate length
 - If we have multiple “ r ”, choose the closest-shortest reference to “ c ”
- Both factors are computed over the whole document

Outline

- MT Evaluation
- Modeling, Training, Decoding
 - Word Alignment
 - Phrase-based Models
 - Tree-based Models

Outline

- MT Evaluation
- Modeling, Training, Decoding
 - Word Alignment
 - Phrase-based Models
 - Tree-based Models

References

- K. Papineni, S. Roukos, T. Ward, and W.-J. Zhu, "Bleu: a method for automatic evaluation of machine translation," in *Proc. of ACL 2002*, pp. 311--318, 2002.
- G. Doddington, "Automatic evaluation of machine translation quality using n-gram co-occurrence statistics," in *In Proc. ARPA Workshop on Human Language Technology*, 2002.
- C.-Y. Lin and F. J. Och, "Automatic evaluation of machine translation quality using longest common subsequence and skip-bigram statistics," in *Proceedings of the 42nd Meeting of the Association for Computational Linguistics (ACL'04), Main Volume*, (Barcelona, Spain), pp. 605--612, July 2004.
- S. Banerjee and A. Lavie, "METEOR: An automatic metric for MT evaluation with improved correlation with human judgments," in *Proceedings of the ACL Workshop on Intrinsic and Extrinsic Evaluation Measures for Machine Translation and/or Summarization*, (Ann Arbor, Michigan), pp. 65--72, June 2005.
- M. Snover, B. Dorr, R. Schwartz, L. Micciulla, and J. Makhoul, "A study of translation edit rate with targeted human annotation," in *In Proceedings of Association for Machine Translation in the Americas*, pp. 223--231, 2006.
- H. Isozaki, T. Hirao, K. Duh, K. Sudoh, and H. Tsukada, "Automatic evaluation of translation quality for distant language pairs," in *Proceedings of the 2010 Conference on Empirical Methods in Natural Language Processing*, (Cambridge, MA), pp. 944--952, Association for Computational Linguistics, October 2010.