

Model	Incorrect
Random	50.0%
BERT (Falke et al., 2019)	35.9%
ESIM (Falke et al., 2019)	32.4%
FactCC (Kryściński et al., 2019b)	30.0%
FactCC (our version)	26.8%

Table 7: Percentage of incorrectly ordered sentence pairs using different consistency prediction models in CNN/DailyMail, using data from Falke et al. (2019).

A Implementation details

For hyperparameter search, we tried 4 layers with 4 heads, 6 layers with 6 heads and 10 layers with 10 heads.

There’re 108.3M parameters in the FASUM model and it takes 2 hours (CNN/DailyMail) / 0.5 hours (XSum) for 4 v100 GPUs to train 1 epoch. The batch size is set to 48 for both datasets.

On validation datasets, FASUM achieves ROUGE-1 41.08%, ROUGE-2 18.35% and ROUGE-L 37.95% on CNN/DailyMail, and it achieves ROUGE-1 30.28%, ROUGE-2 10.09% and ROUGE-L 23.85% on XSum.

B Factual Consistency Evaluator

To automatically evaluate the factual consistency of a summary, we leverage the FactCC model (Kryściński et al., 2019b), which maps the consistency evaluation as a binary classification problem, namely finding a function $f : (A, C) \rightarrow [0, 1]$, where A is an article and C is a summary sentence defined as a claim. $f(A, C)$ represents the probability that C is factually correct with respect to the article A . If a summary S is composed of multiple sentences C_1, \dots, C_k , we define the factual score of S as: $f(A, S) = \frac{1}{k} \sum_{i=1}^k f(A, C_i)$.

To generate training data, we adopt backtranslation as a paraphrasing tool. The ground-truth summary is translated into an intermediate language, including French, German, Chinese, Spanish and Russian, and then translated back to English. Together with the original summaries, these claims are used as positive training examples. We then apply entity swap, negation and pronoun swap to generate negative examples (Kryściński et al., 2019b).

Following Kryściński et al. (2019b), we finetune the BERT_{BASE} model using the same hyperparameters to finetune FactCC. We concatenate the article and the generated claim together with special tokens [CLS] and [SEP]. The final embedding of

[CLS] is used to compute the probability that the claim is entailed by the article content.

As shown in Table 7, on CNN/Daily Mail, our reproduced model achieves better accuracy than that in Kryściński et al. (2019b) on the human-labelled sentence-pair-ordering data (Falke et al., 2019). Thus, we use this evaluator for all the factual consistency assessment tasks in the following.³

C Examples

Table 8, 9 and 10 show examples of CNN/DailyMail articles and summaries generated by our model and several baseline systems. The factual errors in the summary are marked in red, the correct facts in the summaries of FASUM are marked in green and the corresponding facts are marked in bold in the article.

As shown, while baseline systems like BOTTOMUP and UNILM achieve high ROUGE scores, they are susceptible to factual errors. For instance, in Article 5, both BOTTOMUP and SEQ2SEQ wrongly state that Rickie Fowler accused Alexis. In fact, Alexis, Rickie’s girlfriend, was accused by an online hater. In Article 1, UNILM mistakenly summarizes that Arsenal lost 4-1 where in fact Arsenal won 4-1 against Liverpool.

In comparison, our proposed fact-aware summarizer FASUM could faithfully summarize the salient information in the article. And it can reorganize the phrasing instead of merely copying content from the article.

Table 11 and Table 12 show examples of CNN/DailyMail articles, summaries generated by BOTTOMUP/UNILM and the corrected version by FC. As shown, our correction model can select the wrong entities and replace them with correct ones. For instance, in Article 1, BOTTOMUP’s summary states that Rual Castro, who appears elsewhere in the article, is the President of Venezuela, while FC correctly replaces it with Nocolas Maduro. In Article 4, UNILM wrongly attributes the statement to Scott’s lawyer (probably because “Scott” appears closer to the statement in the article), while it was actually said by Slager’s lawyer. This error is corrected by FC.

³We use the same setting and train another evaluator for XSum dataset.

Article 1	Arsenal target Raheem Sterling is a more talented player than Gunners star Mesut Ozil, according to Michael Owen. The former Liverpool forward made the claim before Brendan Rodgers' men lost 4-1 at the Emirates on Saturday ... Ozil bends home Arsenal's second goal in their 4-1 win against Liverpool at the Emirates...
Reference	Arsenal are interested in signing Liverpool's Raheem Sterling this summer. The 20-year-old has rejected a new PS100,000-a-week deal at Anfield. Michael Owen believes Sterling is more talented than Mesut Ozil . Adrian Durham: Sterling would be earning the same as Balotelli if he signed PS100,000-a-week deal at Liverpool... Durham: Arsenal only turn it on when the pressure is off. The German scored in Arsenal's 4-1 win against Liverpool on Saturday...
BOTTOMUP	Raheem Sterling made the claim before Brendan Rodgers' men lost 4-1 at the Emirates on Saturday. Bt Sport pundit Owen believes there should not be a debate about whether Sterling is more talented than Ozil. The former Liverpool forward is a better player than Mesut Ozil.
UNILM	Michael Owen believes Raheem Sterling is a better player than Mesut Ozil. Owen made the claim before Arsenal lost 4-1 at the Emirates on Saturday. Owen's opinion drew criticism on social media but the former Liverpool forward has refused to back down. Owen said : ' Is there a debate? Not even close' CLICK HERE for all the latest Arsenal news.
FASUM	Michael Owen says there should not be a debate about whether Raheem Sterling is more talented than Mesut Ozil. The former Liverpool forward made the claim before Brendan Rodgers' men lost 4-1 at the Emirates on Saturday. Owen repeated his claim that the wantaway forward is a superior player than Ozil made.
SEQ2SEQ	Michael Owen made the claim before Liverpool's men lost 4-1 at the Emirates on Saturday. Michael Owen believes there should be a debate about whether Sterling is more talented than Ozil. The ex-England striker has refused to back down, even after Sterling's poor display in north London.
Article 2	Yaya Toure was accused by Jamie Carragher of ducking out of the way of Jason Puncheon's free-kick which killed off Manchester City's hopes of salvaging something from Selhurst Park. Toure, who is paid PS200,000-a-week , was part of a five-man wall when Puncheon stepped up to double Crystal Palace's lead...
Reference	Crystal Palace beat Manchester City 2-1 at Selhurst Park on Monday night. Jason Puncheon's free-kick doubled Palace's lead in the second half. Yaya Toure was accused of ducking out of the way of the winning goal. Sportsmail's Jamie Carragher : 'The rest of them are desperate to be hit with the ball in the face and it's poor from Yaya Toure' Gary Neville: City have a mentality problem... they cannot sustain success.
BOTTOMUP	Yaya Toure was accused by Jamie Carragher out of the way of Jason Puncheon's free-kick at Selhurst Park on Monday. Toure, who is paid 200,000-a-week, was part of a wall with Crystal Palace's lead . Carragher said the midfielder did not do enough to prevent the winner.
UNILM	Yaya Toure was accused by Sportsmail's Jamie Carragher of ducking out of the way of Jason Puncheon's free-kick at Selhurst Park on Monday. The midfielder was part of a five-man wall when Puncheon stepped up to double Crystal Palace's lead. Toure is paid 200,000-a-week a by the Premier League champions .
FASUM	Yaya Toure was accused by Jamie Carragher of ducking out of the way of Jason Puncheon's free-kick. Fernandinho and Vincent Kompany look keen to get their head to the ball but Toure appears to duck. Toure paid PS200,000-a-week , was part of a five-man wall when Puncheon stepped up to double Crystal Palace's lead .
SEQ2SEQ	Jamie Carragher was accused of ducking out of the way of Jason Puncheon's free-kick which killed off Manchester City's chances at Selhurst Park on Monday Night. Toure is paid PS200,000-a-week, was part of a five-man wall when Puncheon stepped up to double Palace's lead. Sportsmail columnist Jamie Carragher feels City midfielder did not do enough to prevent winner.

Article 3	Real Madrid ace Gareth Bale treated himself to a Sunday evening BBQ after ... a sensational victory. The Welsh wizard was ... scoring twice and assisting another in an impressive victory in Israel... he opened the scoring in Real Madrid's impressive 9-1 victory ... His goal in the 25th minute may have got the ball rolling ... Cristiano Ronaldo scored five goals against Granada on Sunday ...
Reference	Welsh Wizard Gareth Bale opened the scoring in Sunday's stunning win. Real Madrid put nine goals past Granada to keep pressure on Barcelona. Bale treated himself to a BBQ in the Spanish sun following victory. Cristiano Ronaldo scored five goals in the sensational team performance.
BOTTOMUP	Gareth Bale scored twice in Real Madrid's 9-1 victory against Granada. The Real Madrid ace scored five goals against Granada on Sunday. The Welsh wizard was in impressive form for the international break.
UNILM	Gareth Bale scored twice as Real Madrid beat Granada 9-1. The Welsh winger scored for Wales away on international duty. Bale Tweeted:'Unbelievable result this afternoon, great team performance. Now for a BBQ' Real Madrid bounced back from El Clasico defeat by Barcelona with a thumping win. Cristiano Ronaldo scored five goals against an eight-minute hat-trick.
FASUM	Real Madrid beat Granada 9-1 at the Bernabeu on Sunday evening. Gareth Bale scored twice and helped his side to a sensational 9-1 win. Cristiano Ronaldo scored five goals against Granada on Sunday. The Welsh winger Tweeted:'Unbelievable result this afternoon, great team performance now for a BBQ'
SEQ2SEQ	Gareth Bale scored twice as Real Madrid beat Granada 9-1 at the Bernabeu on Sunday. The Welsh ace opened the scoring with a goal against Granada in the 25th minute. Gareth Bale scored five and assisted another in an impressive win in Israel. Bale Tweeted:' Unbelievable result this afternoon, great team performance. Now for a BBQ'
Article 4	Former Huddersfield centre Josh Griffin scored a try and kicked three goals as improving Salford secured back-to-back Super League wins with an 18-12 triumph at the John Smith's Stadium. Griffin and Ben Jones-Bishop scored tries in the first half, although Jack Hughes gave the Giants hope. Carl Forster's try and Griffin's penalty made the game safe... Salford Red Devils secured a second win?...
Reference	Salford sealed consecutive Super League wins with victory at Huddersfield. Josh Griffin inspired Red Devils with a try and three kicked goals. Ben Jones-Bishop and Carl Forster scored the other tries for the visitors.
BOTTOMUP	Josh Griffin and Ben Jones-Bishop scored tries in the first half. Salford Red Devils win a second win in a row with a 18-12 victory at Huddersfield. Carl Forster scored a try and kicked three goals for Salford.
UNILM	Former Huddersfield centre Josh Griffin scored a try and kicked three goals. Ben Jones-Bishop scored tries in the first half. Carl Forster's try and Griffin's penalty made the game safe.
FASUM	Former Huddersfield centre Josh Griffin scored a try and kicked three goals as Salford secured back-to-back Super League wins with an 18-12 win at John Smith's Stadium. Ben Jones-Bishop scored tries in the first half but Jack Hughes gave the Giants hope. Carl Forster's try and Griffin's penalty made the game safe, though.
SEQ2SEQ	Huddersfield centre Josh Griffin scored a try and kicked three goals. Griffin scored tries in the first half for the Giants. The game was twice delayed early on when Kevin Locke for Huddersfield's Brett Ferres were carried off injured.

Table 9: Continuation of Table 8.

Article 5	Rickie Fowler has earned extra brownie points with his growing legion of fans after calling out an online hater who accused his girlfriend of being a ‘gold digger.’ The golfer’s girlfriend, bikini model Alexis Randock, had posted a photo on her Instagram account of her and sister Nicole on the beach last week... an abusive commenter known as ‘fatalsplash’ who was quick to judge and accused Alexis of being a ‘gold digger.’ ... Fowler told the hater to ‘get your facts straight’ ...
Reference	Rickie Fowler responded to online troll who abused his girlfriend. Bikini model Alexis Randock had posted a photo on her Instagram account. Randock was pictured on the beach alongside her sister Nicole. A troll called ‘fatalsplash’ then accused Alexis of being a ‘gold digger’ Fowler told the hater to ‘get your facts straight’ following comment.
BOTTOMUP	Rickie Fowler accused Alexis of being a ‘gold digger’ who did n’t have to work. The golfer was criticised by an online troll for not working due to her relationship with Fowler. Fowler has earned extra brownie points with his legion of fans.
UNILM	Rickie Fowler ’s girlfriend, bikini model Alexis Randock, posted a photo on her Instagram account of her and sister Nicole on the beach last week. An abusive commenter called ‘fatalsplash’ accused Alexis of being a ‘gold digger’
FASUM	Rickie Fowler has earned extra brownie points with his growing legion of fans. The golfer’s girlfriend, bikini model Alexis Randock, had posted a photo on her Instagram account. The photo was shared with her 25,000 followers, which included an abusive commenter known as ‘fatalsplash’ who was quick to judge and accused Alexis of being a ‘gold digger’
SEQ2SEQ	Golfer’s girlfriend posted a picture of her and sister Nicole Randock on Instagram. The picture shared with her 25,000 followers was shared by her sister on the beach last week. The golfer was quick to judge and accused Alexis of being a ‘gold digger’ troll . He responded by posting the caption ‘fatalsplash’ accusing her of being ‘a digger who didn’t work for it’
Article 6	The VII Summit of the Americas was supposed to be all about the symbolic handshake between the United States and Cuba... Heads of state from 35 countries in the Western Hemisphere have met every three years... Obama and Castro would come face-to-face... Venezuelan President Nicolas Maduro recently accused the United States of trying to topple his government...
Reference	U.S., Venezuelan relations threaten to overshadow Obama, Castro meeting. Venezuelan President says United States moved to oust him; he has the support of the Cuban foreign minister.
BOTTOMUP	Heads of state from 35 countries have met every three years to discuss economic, social or political issues since the summit in 1994. Venezuela’s President Raul Castro has been criticized for human rights violations. The U.S. government says the summit of the Americas is a “triangle of tension.”
UNILM	Summit of the Americas was supposed to be all about the symbolic handshake between the U.S. And Cuba. The tide changed when President Obama and Castro announced that more than five decades of Cold War rivalry was ending. Venezuelan President Nicolas Maduro recently accused the U.S. Of trying to topple his government...
FASUM	The summit of the Americas was supposed to be all about the symbolic handshake between the u.s. and Cuba. Diplomats from both countries began negotiations to establish embassies in Havana and Washington . President Nicolas Maduro recently accused the United States of trying to topple his government.
SEQ2SEQ	The VII summit of the Americas was supposed to be all about the symbolic handshake between the United States and Cuba. Relations between the u.s. and Cuba have been the wrench in diplomatic machinery, with some Latin American leaders threatening not to attend. President Barack Obama and Castro face-to-face embassies in Havana and Washington.

Table 10: Continuation of Table 8.

Article 1	The VII Summit of the Americas was supposed to be all about the symbolic handshake between the United States and Cuba. But insert Venezuela into the mix and Panama City, Panama, quickly turns into a “triangle of tension.”... Cuba has historically been the wrench in the diplomatic machinery, with some Latin American leaders threatening not to attend the Summit of the Americas if the United States and Canada didn’t agree to invite President Raul Castro... The much anticipated handshake between Obama and Castro would steal all the headlines if it wasn’t for Cuba’s strongest ally, Venezuela. Venezuelan President Nicolas Maduro recently accused the United States of trying to topple his government and banned former President George Bush...
BOTTOMUP	Heads of state from 35 countries have met every three years to discuss economic, social or political issues since the summit in 1994. Venezuela’s President Raul Castro has been criticized for human rights violations. The u.s. government says the summit of the Americas is a “triangle of tension.”
Corrected by FC	Heads of state from 35 countries have met every three years to discuss economic, social or political issues since the summit in 1994. Venezuela’s President Nicolas Maduro has been criticized for human rights violations. The u.s. government says the summit of the Americas is a “triangle of tension.”
Article 2	She’s one of the hottest and most successful Latinas in Hollywood, but now Sofia Vergara is playing defense in a legal battle initiated by her ex-fiance: He wants to keep the two frozen embryos from their relationship, both female. The 42-year-old actress and star of the hit TV sitcom "Modern Family" split from businessman Nick Loeb in May 2014. Loeb is suing the Colombian-born actress in Los Angeles to prevent Vergara from destroying their two embryos conceived through in vitro fertilization in November 2013, according to published reports by New York Daily News and In Touch magazine...
BOTTOMUP	Sofia Vergara wants to keep the frozen embryos from their relationship, both female. He is suing the actress in Los Angeles to prevent Vergara from their embryos. The actress and star of the “Modern Family” split from Nick Loeb in May 2014.
Corrected by FC	Nick Loeb wants to keep the frozen embryos from their relationship, both female. He is suing the actress in Los Angeles to prevent Vergara from their embryos. The actress and star of the “Modern Family” split from Businessman Nick Loeb in May 2014.
Article 3	Volvo says it will begin exporting vehicles made in a factory in southwest China to the United States next month, the first time Chinese-built passenger cars will roll into American showrooms. Parent company Geely Automobile , which bought Volvo in 2010, is seeking to prove that a Chinese company can manage a global auto brand...
BOTTOMUP	Volvo is seeking to prove that a Chinese company can manage a global auto brand. The car will be one of four models produced in a manufacturing plant in Chengdu. China is largest market for car sales globally in 2009.
Corrected by FC	Geely Automobile is seeking to prove that a Chinese company can manage a global auto brand. The car will be one of four models produced in a manufacturing plant in Chengdu. China is largest market for car sales globally in 2009.

Table 11: Example articles, summaries and corrections made by FC in CNN/DailMail. The factual errors in the original summary are marked in red, the corrected part by FC are marked in green and the corresponding facts are marked in bold in the article.

Article 4	... Scott family attorney Chris Stewart said the man with Scott was a co-worker and friend... Slager has been fired and faces life in prison or the death penalty if convicted on a murder charge. Video shot by a witness shows the officer shooting Scott in the back as he runs away. Slager had told investigators he feared for his safety after he and Scott tussled over his Taser. His lawyer , Andy Savage, said Friday he “has not received the cooperation from law enforcement that the media has.” ...
UNILM	“This is a heartbreaking tragedy for everyone in our community,” Charleston mayor says. Scott family attorney says the man with Scott was a co-worker and friend. Michael Slager has been fired and faces life in prison or the death penalty if convicted on a murder charge. Scott ’s lawyer says he “has not received the cooperation from law enforcement that the media has
Corrected by FC	“This is a heartbreaking tragedy for everyone in our community,” Charleston mayor says. Scott family attorney says the man with Scott was a co-worker and friend. Michael Slager has been fired and faces life in prison or the death penalty if convicted on a murder charge. Slager ’s lawyer says he “has not received the cooperation from law enforcement that the media has
Article 5	Rangers boss Stuart McCall has revealed he was warned about taking over at Ibrox by Walter Smith - but insists he has made the right decision. The former Light Blues midfielder steered his new side to their third victory on the bounce with Sunday’s 2-1 win over Hearts. It was a crucial triumph that moves Gers back into second place in the Scottish Championship and looks to have restored vital momentum ahead of the end-of-season play-offs. Stuart McCall says he was warned not to take the Rangers job but is pleased that he took the risk in the end.
UNILM	Stuart McCall guided Rangers to a 2-1 win over Hearts on Sunday. Kenny Miller and Haris Vuckic scored the goals for the Gers at Ibrox. The win moved Rangers back into second place in the Scottish Championship. The Gers boss says he was warned not to take over by Walter Smith. But he says he is pleased that he took the risk in the end.
Corrected by FC	Stuart McCall guided Rangers to a 2-1 win over Hearts on Sunday. Kenny Miller and Haris Vuckic scored the goals for the Gers at Ibrox. The win moved Gers back into second place in the Scottish Championship. The Rangers boss says he was warned not to take over by Walter Smith. But he says he is pleased that he took the risk in the end.
Article 6	Wasps will appeal against the three-week ban issued to Nathan Hughes , but their protest will not enable the back row to play in Sunday’s Champions Cup quarter-final against Toulon. The club have said in a statement they will appeal on the grounds the incident that left Northampton wing George North unconscious and resulted in a red card for Hughes was an accident and no foul play had occurred... Wasps are set to appeal the three-match ban handed to No 8 Nathan Hughes for knocking out George North ... Hughes was given the suspension - to include three meaningful fixtures - after being found guilty of striking North in the 52-30 Aviva Premiership defeat at Franklin’s Gardens on March 27...
UNILM	Wasps will appeal the three-match ban handed to No 8 Nathan Hughes. The Northampton winger was found guilty of striking George North. The incident occurred during Northampton ’s 52-30 defeat at Franklin’s Gardens. North suffered a third confirmed concussion in just four months.
Corrected by FC	Wasps will appeal the three-match ban handed to No 8 Nathan Hughes. The Wasps winger was found guilty of striking George North. The incident occurred during Wasps ’s 52-30 defeat at Franklin’s Gardens. North suffered a third confirmed concussion in just four months.

Table 12: Continuation of Table 11