Figure 4: We validated the increasing concern in *loss of control* on Reddit data. The y-axis measures the percentage of AI-related comments that mention loss of control of AI.

News Articles from 1956 to 1986

The New York Times provides full text for articles published after 1986, but article *abstracts* (short descriptions of article content) are available over a much longer time period. To extend our results, we collected a dataset of all abstracts published between 1956 (the year of the first AI workshop at Dartmouth) and 1986. Articles that mention AI are less common over this earlier period, with only 40 abstracts that reference AI (the first appears in 1977) and 247 that mention robots. These data are too sparse to extend our earlier analyses to 1956, but we have manually annotated each abstract with topic keywords to observe themes over time.

In the 1950s, robots are most associated with military applications and especially missiles, e.g., "the guided missile—the almost human robot of the skies." The 1960s and 70s strongly emphasize space, as in "a ten-pound robot was shot into orbit today." Interest in AI picks up considerably in the early 1980s, where we see the first article that worries AI will negatively impact human jobs, the first reported death via robot, "a factory worker killed by a robot arm," and the first mention of AI in healthcare, "a robot to prepare meals and perform other chores for quadriplegics."

External validity

Do the trends we have discovered in the New York Times generalize to the public at large? While this question is difficult to answer directly, we have replicated one of our primary findings on 5 years of public posts from Reddit, a popular online community with a diverse set of users.

Concretely, we train a classifier to predict the presence of *loss of control* in paragraphs about AI using our annotated data from the New York Times. We then apply this classifier to posts made by Reddit users. We use a logistic regression model based on TF-IDF features and threshold the positive class probability at 0.9. In validation, we observe precision of 0.8 on a sample of 100 Reddit posts annotated with ground truth. Finally, we apply this classifier to every post that mentioned "artificial intelligence" from 2010 to 2015.

We present the resulting trend in Figure **??**, which mirrors Figure 3M over the same time period. Broadly, this replication suggests that attitudes among Reddit users shift in line with what we see in the New York Times, providing some evidence for the external validity of our findings.

Related Work

Others have discussed the impact of artificial intelligence on society and the range of future outcomes (**?**). These discussions are in part driven by a need to address public concerns about AI—our work is the first to quantify such concerns through direct analysis. The set of indicators we have introduced will be useful in framing future discussions, such as those ongoing in the One Hundred Year Study of Artificial Intelligence (**?**).

Public opinion polls have similarly measured topics relevant to AI. While such polls are recent (and not conducted over time), they support our findings, showing greater levels of optimism than pessimism about AI, but increasing existential fear and worry about jobs (**?**; **?**). Future polls might allow us to directly measure public opinion on the set of measures we have studied.

Beyond artificial intelligence, other work has mined cultural perspectives from text corpora over long time periods. For example, by analyzing 200 years of data from Google Books, it is possible to quantify the adoption of new technologies or changes in psychological attitudes through linguistic patterns (**?**; **?**). Using music, others have quantified changes in artistic style over a 40 year period (**?**). We use crowdsourced annotations to extend the limits of what is possible under these kinds of quantitative analyses.

News and social media offer a powerful reflection of public attitudes over time. For example, by analyzing such data, it is possible to predict cultural events such as revolutions (**?**; **?**), or examine public opinion on same-sex marriage (**?**). Here we use such data to discover and validate similar trends in the public perception of artificial intelligence.

Finally, crowdsourcing is a powerful tool for enabling new kinds of quantitative analyses. For example, it is possible to crowdsource lexicons of words to answer novel research questions (**?**), or leverage crowds to bootstrap classifiers that can then be applied to much larger corpora (**?**; **?**). Here we use crowds to identify themes in articles that would be difficult to analyze under fully automated approaches.

Conclusion

We present a set of indicators that capture levels of engagement, general sentiment, and hopes and concerns for the future of artificial intelligence over time. We then validate these impression indicators by studying trends in 30 years of articles from the New York Times. We find that discussion of AI has increased sharply since 2009 and has been consistently more optimistic than pessimistic. However, many specific concerns, such as the fear of loss of control of AI, have been increasing in recent years.

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