REPORT 2018

THE STATE OF DEEPFAKES: *REALITY UNDER ATTACK*

DEEPTRACE

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ABOUT THIS REPORT

In recent years, rapid advances in the development of AI has led to the technology being commoditized for a variety of positive applications. However, these technological advances are also increasingly being exploited by bad actors for malicious uses. This report will specifically focus on the malicious uses of AI enabled video synthesis, popularized under the broader name of ‘deepfakes’.

The report is the first to trace the evolution of this technological and social phenomenon. The reference timeline is 2017-2018, with an outlook to 2019. Data is collected up to 20/12/2018.

About the authors DeepTrace B.V. is a Private Limited company founded in 2018 in Amsterdam, the Netherlands. DeepTrace's mission is to empower people in understanding and trusting what they see. The company is building technologies for fake videos detection and understanding. This document follows the company goal by studying the new phenomenon and its societal impact, with the aim of increasing public awareness and devising technological solutions to its threat.

Cite: The state of deepfakes: reality under attack, Giorgio Patrini and Francesco Cavalli, Annual Report v.2, 2018.

GLOSSARY

AI: Artificial Intelligence, a branch of computer science that aims to replicate features of human intelligence in software.

DARPA: Defense Advanced Research Projects Agency, an agency of the United States Department of Defense.

Deepfake: A portmanteau of "deep learning" and "fake", any photo-realistic audiovisual content produced with the aid of deep learning. It also refers to the technology creating it. The term implies its misuse for illicit or unethical purposes.

It is derived from the Reddit user "deepfakes", who was the first to publicly document attempts to synthetically replace the face of a target person with the face of another person, i.e. a face swap, in pornographic videos. The term has widen its meaning throughout 2018 to include other techniques such as facial expression re-enactment, full body and background manipulation as well as audio synthesis.

In some occasions, even videos doctored with elementary zoom, speedup or frames reordering have been referred to deepfakes by the press, a use of the term we do not encourage.

Deep learning: class of AI methods based on deep neural networks for tasks such as supervised and unsupervised learning and generation.

GAN: Generative Adversarial Networks, a specific kind of deep learning algorithm that can train a neural network to generate realistic imagery. Whilst GANs are not integral to creating synthetic media, they represent the most significant development in the how new kinds of synthetic media are created.

KEY FINDINGS

- **2018 summary** Originating from a Reddit community of developers, the deepfakes phenomenon is featured by top media outlets worried about its consequences for journalism, gaining world-wide popularity. The first instances of fake videos for political propaganda and public shaming take place. Several websites ban deepfakes but the lack of reliable technology for fake detection makes its implementation hard. While the US intelligence community grows concern, a Chinese state-owned news broadcaster debuts with a synthetic AI-powered anchor
- **Public awareness** Publication of online articles and videos on deepfakes and their impact is growing steadily in size, as well as Google searches which are 1000x higher than last year
- **Adult industry** The first area that sees a large scale use of fake videos. We count 8K+ fake pornographic videos on adult sites
- **Tech development** An active community of developers is growing around open source projects, creating free and easy to use tools for video forgery
- **Synthesis: quality and quantity** Choosing GAN as a representative technique, we report on the striking growth of number of research papers published per year since 2014, as well as on the achievements on image quality
- **Research on anti forgery** In 2018 we count 25 new research papers aimed at detecting fake imagery. The numbers pales in comparison to 902 papers on GANs
- **Outlook** Experts' opinion generally agrees on expecting high profile, potentially catastrophic effects from the use of fake videos in the period 2019-2020

TIMELINE

2012 The ImageNet image classification competition is won by a significant margin with a deep neural network for the first time. The deep learning "Renaissance" begins

2014 Deep learning researchers make breakthroughs in generative modelling, in particular by introducing the Generative Adversarial Networks (GANs). Yann Lecun, Chief AI Scientist at Facebook will cite them as the “the coolest idea in deep learning in the last 20 years"

2016 DARPA's Media Forensics starts 4 years funding programs for research on new methods for digital forensic

2016 Computer vision researchers publish "Face2Face", a new method for facial re-enactment: it is possible to transfer facial expressions from one person into another person's video, in real time

2017 UC Berkeley presents "Cycle GAN" that can transform images and videos into a version with a different style, e.g. a different season

2017 The Washington University publishes "Synthesizing Obama: Learning Lip Sync from Audio": a method for syncronizing lip movement in a video with a speech from a different source

2017 Nov The anonymous reddit user "deepfakes" launches a dedicated subreddit r/deepfakes for sharing porn videos where celebrities faces are swapped with the original ones. The code is built on popular deep learning libraries and soon opensourced. Many videos appear soon on adult websites

2017 Dec Motherboard (Vice) is the first to report about r/deepfakes. Throughout 2018, deepfakes are featured in hundreds of press articles, including mainstream outlets such as The New York Times, Washington Post, The Guardian, The Economist, The Times and BBC

TIMELINE

2018 Jan r/deepfakes gathers over 2500 subscribers

2018 Jan The FakeApp desktop application, built with Google's tensorflow, is released along with tutorials for non-experts

2018 Jan The first site offering deepfakes as a service is alive, run by donations. Later in 2018 more websites will be selling fake videos

2018 Jan-Feb Several websites ban deepfakes, with different degrees of success: Discord, Gfycat, Pornhub and Twitter

2018 Feb r/deepfakes reaches 90K subscribers when it is banned from Reddit for violating the policy "against involuntary pornography"

2018 Feb The first adult website showing solely fake videos goes live

2018 Mar Researchers from the Technical University of Munich and others introduce "FaceForensic", a large-scale video dataset for forgery detection

2018 Apr BuzzFeed tweets a fake video of Barack Obama played by Get Out-director Jordan Peele. The post receives more than 13K retweets, 29K likes and 100K views on Youtube in one day

Credits: Buzzfeed 2018

TIMELINE

2018 Apr Indian journalist Rana Ayyub is targeted by impersonation accounts and porn deepfakes on social media in an effort to silence her

2018 Apr A domestic violence advisory is published by US law professionals titled "Using fake video technology to perpetrate intimate partner abuse"

2018 May Researchers publish "Deep video portraits": the method enables photo-realistic re-animation of portrait videos, using only an input video

2018 May The Belgium Flemish Socialist Party posts a fake video of Donald Trump in which he calls on the country to exit the Paris climate agreement. Officially, it is made "to draw attention to the necessity to act on climate change". Many commenters on Facebook do not realise it is a fake. It is unsure whether deep learning was used for production

2018 May US Senator Marco Rubio voices his concerns about deepfakes at the Senate Intelligence Committee nomination hearing

2018 Jun The University of Alabama presents "In Ictu Oculi": a paper proposing to spot deepfakes based on eyes blinking patterns

2018 Aug UC Berkeley publishes "Everybody dance now": a method for transferring body movements of a person in a source video to a person in a target video

2018 Sep Three US lawmakers send a letter to the Director of National Intelligence demanding a report on deepfakes by mid-December 2018. The letter's authors argue that it could be a national security issue and used by hostile foreign nations

TIMELINE

Credits: Xinhua News Agency 2018

2018 Sep NGO AI foundation raises $10M of capital to develop a tool that combines human moderation and machine learning to identify malicious content meant to deceive people such as deepfakes

2018 Sep Deepmind publishes the "Big GAN" paper, showing high resolution synthesis of many ImageNet objects and animals

2018 Nov The Wall Street Journal shares guidelines on how they are preparing to fight the wave of fake videos in news

2018 Nov State-owned Xinhua News Agency debuts with an AI anchor that can read news for 24 hours a day, showing realistic-looking speech, lip movements and facial expressions

2018 Nov The Washington Times, citing top US officials, warns that America's enemies will use deepfakes to foment 2020 election chaos and "destroy lives"

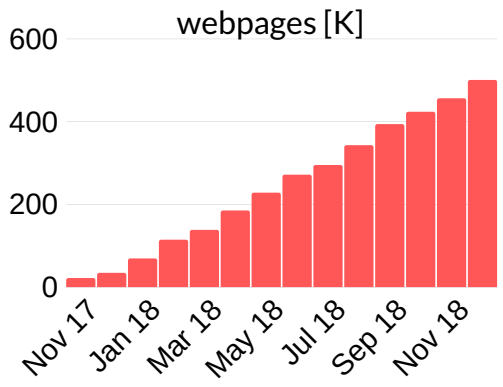
2018 Dec Symanthec Corporation presents a demo for a deepfake detector based on face recognition at BlackHat, London

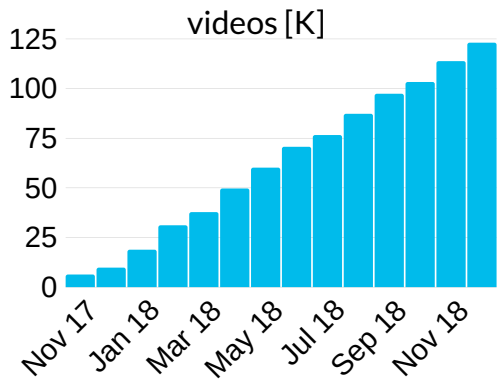
2018 Dec NVIDIA presents "A Style-Based Generator Architecture for GANs", setting the new state of the art in synthetic image quality

INTERNET TRENDS

The widespread publication of articles discussing deepfakes and their impact illustrate increasing public awareness of the deepfake threat. This coincides with the increasing online presence of deepfake videos.

The number of webpages returned by Google search for "deepfake" is growing steadily from last year, as well as for webpages containing related videos. Cumulative statistics:





Until 2017 "deepfake" Google searches globally topped out at 100 per month. With the attention of mainstream media, the keyword attracted between 1M and 10M searches per month, until Jul 2018. The Internet attention stabilised to at most 100K per month until Dec 2018, a 1000x increase prior to the Reddit phenomenon:

1000x

Source: Google, Deeptrace.

ADULT INDUSTRY

The online adult industry is the first to experience large scale effects from the spread of fake videos, driven by consumer demand for face swapping for pornographic use.

Number of deepfake videos hosted by the top 10 adult websites for traffic. It does not take into account *pornhub.com* which has disabled search for "deepfakes", yet still hosts many, despite declaring a ban:

1790+

Number of deepfake videos hosted by adult websites featuring fake video content only:

6174

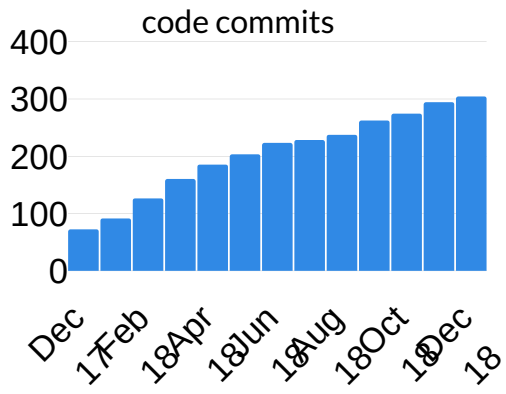
Number of those new websites (all operative since 2018):

Source: Deeptrace.

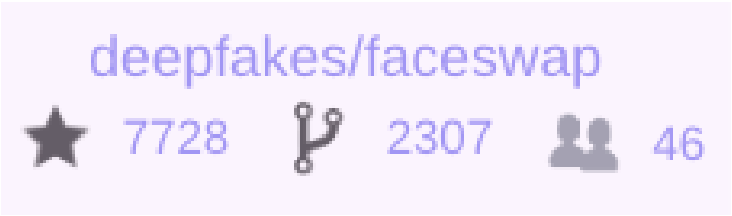
GITHUB DEVS

The commoditisation of tools for video editing and synthesis is contributing to the spread of deepfakes. A community of developers is growing around open source projects.

Cumulative number of code commits to the most popular deep learning Github repository for performing face swaps in videos, *deepfakes/faceswap*:



The size of the community involved with *deepfakes/faceswap* is comparable to that of other industrial-level deep learning libraries. Number of stars, forks and contributors:



davidsand/facenet
6667 2813
30

facebookresearch/Detectron
18138 3723
23

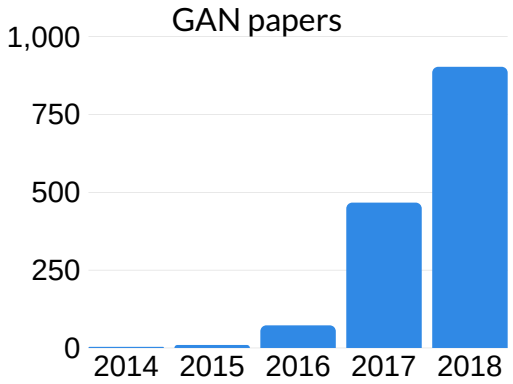
explosion/spaCy
11667 1904
279

Source: Github, Deeptrace.

PROGRESS OF GANS

Since its inception in 2014, the research community working on improving GANs for generative modelling has been very prolific.

Number of papers published on the arXiv (subclasses cs or stat) including "GAN" or "Generative adversarial network" in titles or abstracts has grown to 902 in 2018 only:



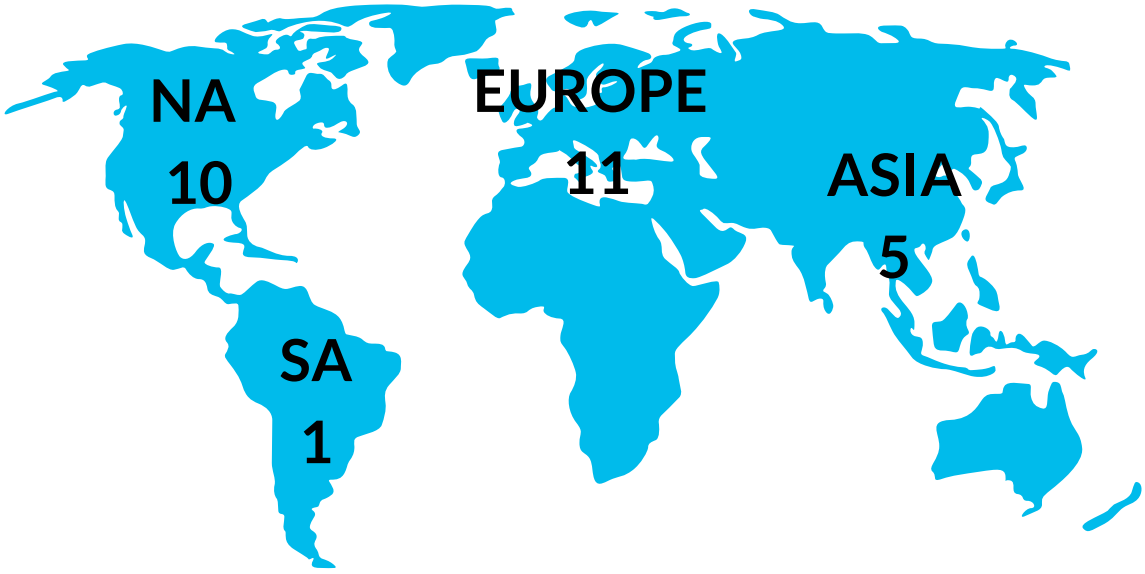
What is striking is also the improvement over image quality. A common benchmark used in research papers is generation of human faces and animals, which we show per year:

Source: arXiv. Image credits: maliciousaireport.com, Salimans et al., Miyato et al., Brock et al., Karras et al.

ANTI-FORGERY PAPERS

Several research institutes are working on deep learning methods for detecting tampered and synthetic imagery. Many are funded by DARPA.

Numbers of papers published by region in 2018. International co-authorships are counted multiple times:



Most prolific in 2018: University Federico II of Naples (Italy), Technical University of Munich (Germany), IDIAP (Switzerland), University of Albany and University of Maryland (US)

25 Papers on the topic published in 2018, also including non-peer reviewed one. 12 are funded by DARPA.

902 In contrast, GANs papers uploaded on the arXiv in 2018 (data from the previous page)

Source: Deeptrace, arXiv.

2019 OUTLOOK: OPINIONS

My assumption is that by 2020, this stuff has spread a bit farther and become cheap enough so that we've enlarged the pool of jokers sufficiently so that somebody does this.
Jack Clark, Policy Director at Elon Musk founded OpenAI
[IEEE Spectrum]

2019 will be the year that a malicious 'deepfake' video sparks a geopolitical incident. We predict that within the next 12 months, the world will see the release of a highly authentic-looking malicious fake video which could cause substantial damage to diplomatic relations between countries.
Katja Bego, Senior Researcher at NESTA
[NESTA]

We are not likely to be awash in deepfakes anytime soon. This technology will remain, for the near-term, a narrow technique likely to be leveraged by states and other well-resourced actors. That's particularly true in a world where there are significantly cheaper and equally effective means of spreading disinformation.
Tim Hwang, Director at Harvard-MIT Ethics and Governance of AI Initiative
[The Pointer Institute]

Source: IEEE Spectrum, NESTA, The Poynter Institute.

2019 OUTLOOK: OPINIONS

The first wave of deepfakes and maliciously synthesized media is likely to be upon up in 2019. We have the opportunity to be prepared.
Samuel Gregory, Programme Director at WITNESS

[World Economic Forum]

I spoke recently with one of the most senior U.S. intelligence officials, who told me that many leaders in his community think we're on the verge of a deepfakes "perfect storm." [...] First, this new technology is staggering in its disruptive potential yet relatively simple and cheap to produce. Second, our enemies are eager to undermine us. [...] China will eventually be incredibly good at this, and we are not ready.
Ben Sasse, US Senator

[Washington Post]

The world's largest democracy, India, will hold general election in 2019, while the world's second largest democracy, the US, will begin the lead up to its 2020 presidential campaign. These elections are likely to trigger the production of sophisticated deepfake content made to manipulate and misinform the public. […] 2019 will see Internet service providers, operators and regulators look seriously into mitigating deepfake content.
Telanor Research

[Telanor]

Source: World Economic Forum, Washington Post, Telanor.

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