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On Dual-Use Information Technology

While I am writing this column, the Russia–Ukraine war is raging. As bombings, destruction, and human suffering flood the daily news, I deeply feel the pain of our Ukrainian colleagues, those who have friends and family in the affected areas, those who had to put their studies and careers on hold to fight for their survival. I also acknowledge the agony of those around the world who are watching the developments in horror, trying to comprehend why such insanity was necessary.

In just three weeks since the Russian invasion, the war has displaced 2.6 million people, according to United Nations estimates. This new wave of refugees has been added to the over 10 million refugees from west Asia, who were forced out of their homes by military conflicts over the past 10 years. This new humanitarian disaster comes as the world is coming out of the grip of the COVID-19 pandemic, which has caused a global death toll of over 5.5 million and counting.

In our digital era, in addition to the physical violence caused by tanks and artillery, the war is fought in the cybersphere. I am sure many of us are wondering to what degree the technologies that we develop can be used, or perhaps already have been used, to cause human suffering.

Signal processing researchers and practitioners are pushing the envelope in speech and language processing, image and video processing, study of the brain, radar, information forensics and security, health monitoring, artificial intelligence, among many other areas, always with the goal to benefit humanity. However, the very research that we produce with the best intentions can be used to launch attacks against humanity.

In life sciences, research that is intended to provide a clear benefit, but which could also be misapplied to pose a threat to public health and safety is referred to as "Dual Use Research of Concern" [1]. An example of such research is the study of viruses. Scientists often create modified versions of dangerous viruses to study how they affect humans and animals, and how they can be fought. At the same time, these viruses have the potential to cause great harm if not handled with care, or if allowed by malicious actors to infect people or animals. While the risk of misuse is always present, there are regulations that preserve the benefits of life sciences research while minimizing the risk of misuse (see, for example, [1] for the U.S. policy on this issue).

It is clear that the very idea of good and bad uses of information technology is subject to interpretation, and it is very difficult to develop regulations that minimize the risk of information technology misuse.

In engineering and information technology, information processing and algorithms also have the potential to be used in ways that can harm the public health and safety, and create a risk to national security. Our information technology can be used to spread misinformation and create confusion. Machine learning algorithms can be manipulated to reach the wrong conclusions. Controllers of critical infrastructure can be infected by malware and turned into tools of destruction [3]. Brain imaging technology, aided by machine learning algorithms, can provide clues on decision-making, opening up the road to develop interventions. In [4] and [5] Functional Magnetic Resonance Imaging (fMRI) was used to study brain activity around the amygdala, which is linked to emotion, and showed that the subject's political orientation is reflected in that activity. Machine learning coupled with fMRI has the potential to translate the language of the brain, and identify thoughts and memories of human subjects [6]. And while fMRI requires the subject to be in a laboratory setting, with advances in near infrared spectroscopy (NIRS), brain activity can be captured via sensors that a person can wear while moving. This opens up possibilities to deploy mind-reading technologies in situations outside the laboratory [2]. While brain-reading technology can aid physically challenged people, it is not difficult to also see how it can also pose a privacy threat to humans, and how in the wrong hands it can be a powerful tool for extracting security-related information from a subject without their consent. Brain stimulation technologies, originally developed to diagnose and treat mental illness, can be

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used in conjunction with brain imaging to influence people's thinking processing. For example, [7] suggests that transcranial direct current stimulation (tDCS) can be used to reduce bias "toward members of social out-groups." It is easy to see how this can be further developed by authoritarian regimes to suppress the opinions of citizens.

It is clear that the very idea of good and bad uses of information technology is subject to interpretation, and it is very difficult to develop regulations that minimize the risk of information technology misuse [2]. Regulators may lack the training to understand the technical details, and as a result, they may miss potential problems, or impose over-restrictive laws that will inhibit future progress. It is therefore important that academics and technology experts work together with policy makers and social scientists in identifying meaningful policies that advance information technology, such as artificial intelligence, machine learning, autonomous intelligent systems, while also ethically integrating them into society. In the meantime, it is important to develop education curricula that emphasize the ethical uses of technology and the potential toll of technology misuse.

I really hope that by the time this article appears in *IEEE Signal Processing Magazine*, the Russia–Ukraine war will have ended and peace will have prevailed. Even in that case, the road to recovery will be long. Some ways the community can support colleagues and their families in Ukraine include:

- Unicef: https://www.unicefusa.org/
- Doctors Without Borders: https://www.doctorswithoutborders.org/
- Red Cross—Red Crescent Ukraine: https://donate.redcrossredcrescent.org/ua/donate/~my-donation

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