WELCOME FROM AJAY AND SHIVON

It's our pleasure to welcome you to Toronto for our fourth annual conference *Machine Learning and the Market for Intelligence*.

> "You can see the computer age everywhere but in the productivity statistics."

So stated Nobel laureate and MIT economics professor Robert Solow in 1987. Eventually, economists found where the productivity gains from the computer age were hiding: in the future. They eventually showed up. They took longer than expected because they were tied to investments in complements.

That is the theme of this year's conference: complements. As in the computer age, the wide-spread productivity gains associated with machine intelligence will depend on investments in complements – all the things other than algorithms/models that are necessary to make commercial-grade AI work (data, redesigned workflows, training, regulation, human judgment, infrastructure, etc.). Throughout the conference, we'll explore the role of complements via a multitude of perspectives.

As in prior years, our focus is not on the technical details of machine learning – the underlying mathematics, statistics, and algorithms – but rather on the economic and social implications of commercial-grade AI. Hence, our choice of complements as this year's theme.

Our choice was inspired by a 1990 essay in the *American Economic Review* by Stanford economist Paul David, who responded to Professor Solow's productivity paradox remark by examining the history of electrification after 1900. David's key insight was that the productivity gains took a surprisingly long time after the initial invention due to the many other complementary investments required to fully realize the new technology's benefits. For example, factories had to be entirely redesigned in terms of layout (single-story rather than multi-story to enable efficiency gains from material handling and workflow) and machinery (more modular, directed by unit drives rather than group drives so that downtime for one machine did not require downtime for all) to fully benefit from distributed electricity.

As David wrote: "At the turn of the century, farsighted engineers already had envisaged profound transformations that electrification would bring to factories, stores, and homes. But the materialization of such visions hardly was imminent. In 1899 in the United States, electric lighting was being used in a mere 3 percent of all residences (and in only 8 percent of urban dwelling units); the horsepower capacity of all (primary and secondary) electric motors installed in manufacturing establishments in the country represented less than 5 percent of factory mechanical drive. It would take another two decades, roughly speaking, for these aggregate measures of the extent of electrification to attain the 50 percent diffusion level."

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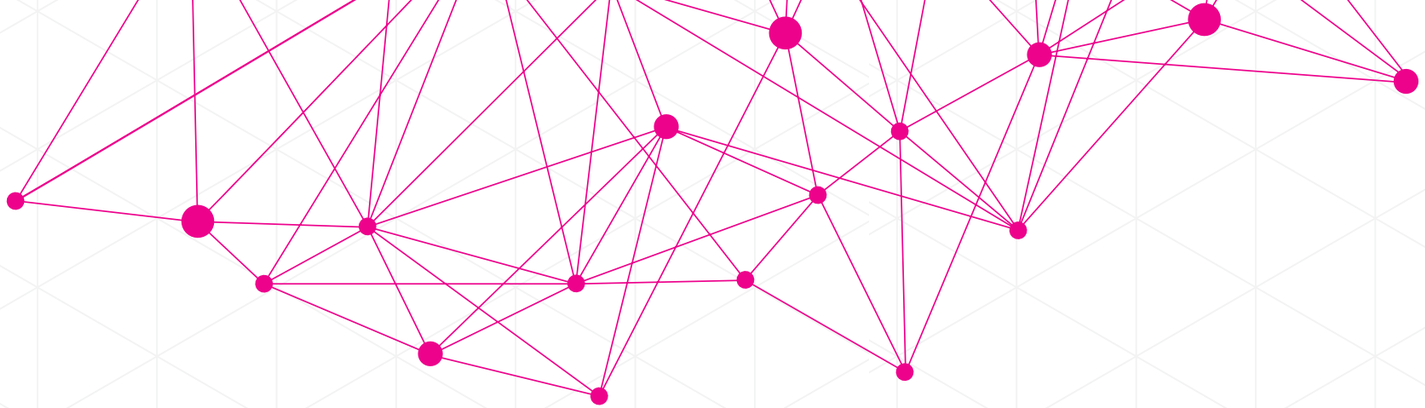

As we shift from technical achievements in AI ("look everyone! the AI can read a handwritten address on an envelope," "the AI can drive a car," "the AI can classify a medical image") to large-scale commercial deployment, the design and implementation of complements will be paramount.

The computer scientists designing AIs are far ahead of those building the complements – industry practitioners, social scientists, regulators, and the like. Now that everyone has realized the sweeping potential of AI, companies and countries are racing to create and control the complements. It's not surprising that we're starting to see an uptick in the competition for complements since our conference last year. In fact, we suspect it will be the dominant story in 2019, more so than competition over the algorithms themselves. Furthermore, while the algorithms are software and thus have low barriers to entry (notwithstanding scale advantages with respect to training data), many complements require significant capital expenditure and thus have higher entry barriers. Therefore, competition policy and market dynamics will move even further onto centre stage.

In other words, we are entering the next phase of the AI revolution: competition in the market for AI complements. This will feel different from what we've experienced so far. The genteel competition among computer scientists on display at conferences like NIPS that is based on the performance of new AI algorithms against well-specified technical benchmarks like ImageNet will give way to competition among firms over the ownership and control of scarce complements, such as data, infrastructure, talent, and relationships.

For enterprise, competition in the semi-scientific culture of algorithmic performance against benchmarks was curious and novel. However, competition over complements is familiar territory. And given the size of the prize, this competition is likely to get rough and tumble as corporate AI strategies depend at least as much on complements as algorithms. Intensified competition will increase the pressure on companies to deliver results. Internal debates like the one at Google regarding whether to abandon Project Maven – a collaboration with the US Department of Defence to utilize AI for image analysis that could potentially be used to improve drone strikes – will seem quaint. Furthermore, competition will not only intensify at the company level. Since our conference last year, one country after another announced their National AI Strategy – and most of them read more like industrial than science policy.

Competition over complements is about to become fierce.

Buckle up.

Ajay Agrawal
Founder, Creative Destruction Lab

Shivon Zilis
Project Director, Office of the CEO,
Neuralink & Tesla

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