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From 8-bit to 4K: a leading image formation technology for the future of digital printing and fabrication

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As the printing technology continues to evolve, the next scientific research frontier will most likely focus on digital fabrication technologies for the era of the "Internet of Things" (IoT) and autonomous smart printing technologies. The rapid advancement in computing power and telecommunication capacity has led to democratization of technologies. In another words, contents and knowledge are not only created by technology inventors but also by technology users, who are also involved in the process of storing and distributing this newly created information for easy access of other technology users. The availability of large databases created by technology users, so called "Big Data", provides enormous opportunities for the scientific community to design and test advanced artificial intelligence algorithms to extract and discover hidden patterns and information in these datasets. It has been widely recognized that printing applications on electronics and flexible substrates will be an enabling technology to accomplish this vision. For example, the south Korean government has granted the Printed Electronics Total Solution (PETS) the status of a national project for the global leading technology program. Similarly, the Chinese government has viewed the development of functional printing technologies as an essential tool to develop advanced manufacturing capability and modernize China's economy.

While research foci for the future of digital printing and fabrication are on advanced material and system devices, the functional pattern manufacturing process remains to follow existing binary/multilevel image formation technologies. Although they are adequate to address printing applications at hand, the ever-increasing demands for fully automated print production and high fabrication precision beyond human vision capability have created new challenges and opportunities for the future of digital image/pattern formation technologies. A computational image formation architecture composed of two primary imaging modules: the computational screening module and the adaptive LED exposure system is introduced to solve this problem. In the computational screening module, the tonal resolution at each pixel is elevated from the current industry standard of 8-bit to a class-leading 12-bit, i.e. 4K tonal resolution. Combined with a 1200-dpi high spatial resolution adaptive LED printhead, the proposed image formation architecture can effectively address technological challenges for the future of image formation and digital fabrication technologies. When combined with signal-sensing devices, the proposed computational image formation algorithm can adaptively adjust the exposure signal and achieve the optimal result. Like active-sensing mechanisms equipped on smart phones and autonomous vehicles, this is an example of how computing power can be harvested to push the technological envelop for the next industrial revolution.