Previous Research

My main interests lie in supersymmetric gauge theory and string theory, especially many of their algebra-geometric aspects. More precisely, string theory, as seen from the worldsheet, is equivalent to some 2d conformal field theory (CFT). There is an enormously rich algebraic structure due to the conformal invariance in two dimensions. An immediate example is Wess-Zumino-Witten model where affine Lie algebra is intimately related to Lie group representation theory. On the other hand, CFT can be viewed as a tool which quantizes the moduli space of 2d worldsheets (or Riemann surfaces).

Let me briefly illustrate this algebra-geometric aspect by an example. The best candidate is Knizhnik-Zamolodchikov equation. One can view it as a master equation satisfied by CFT chiral conformal blocks which are thus horizontal sections w.r.t. a flat connection defined on, say, a punctured two-sphere. Although these conformal blocks form a representation of the mapping class group on Riemann surfaces, they can be derived by resorting to only Lie algebra representation theory. Both algebra and geometry are thus unified in one scheme.

Let us turn back to the main topic. One can view gauge and string as one entity because the former corresponds to the open string sector of the later (closed string sector). This conceptual revolution has been introduced owing to the discovery of an extended object, D-brane (Polchinski 1995), which serves as the source of closed strings. Effectively, gauge theory can be thought of as a (d+1)-dimensional worldvolume description of D-branes on which open strings end.

Accompanied by D-branes, the so-called openclosed duality in physics gets realized. Therefore, gauge theory can be understood by means of gravity (or closed string) and vice versa. One celebrated example is the famous AdS/CFT correspondence conjectured by Maldacena in 1997.
Recently, the open-closed duality is extended to a more general framework: gauge/geometry correspondence.

The reason is that, in addition to the aforementioned AdS/CFT, gauge theory has been constructed geometrically by, say, compactifying higher-dimensional spacetime on a suitable manifold and then making gravity decoupled. For instance, 12d F-theory, 11d M-theory and 10d type II string theory compactified on Calabi-Yau threefolds provide us with 6d, 5d and 4d supersymmetric gauge theories respectively (with eight supercharges). Geometric data of Calabi-Yau then definitely rule gauge theory dynamics. Either 4d $N = 2$ prepotential or $N = 1$ superpotential, for instance, can be obtained by computing the topological string amplitude over Calabi-Yau threefolds.