canvasXpress: A versatile interactive high-resolution scientific multi-panel visualization toolkit

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To the Editor: CanvasXpress was developed as the core visualization component for bioinformatics and systems biology analysis at Bristol-Myers Squibb and further enhanced by scientists around the world and served as key visualization engine for many popular bioinformatics tools[1,2,3,4,5,6]. It supports a large number of visualizations as shown at http://canvasxpress.org to display mainly scientific and genomics data that includes sophisticated plots such as oncoprint of cancer mutations, heatmap, 3D scatter, violin, spider, and profile plot as illustrated in Figure 1 that is arranged together by the accompanying html based tool, canvasDesigner (https://baohongz.github.io/canvasDesigner). Recently, reproducibility and usability of the package in real world bioinformatics and clinical use cases have been improved significantly witnessed by continuous add-on features and wide adoption of the toolkit in the scientific communities. Furthermore, It is the first noteworthy package harmonizing real time interactive exploration and analysis of big data, full-fledged customization of look-n-feel, and production of multi-panel publication-ready figures in PDF format simultaneously.

Emphasizing reproducible research, canvasXpress captures all programmatic and user interactions including modifications done through the menus, on plot controls and comprehensive configurator as illustrated at http://canvasxpress.org/html/user-interface.html. The customization is recorded in real time as the user modifying a graph and is embedded in the saved JSON file as metadata. The file can then be opened in a webpage containing a canvasXpress panel to reproduce the exact plot. Please see a step-by-step example at http://canvasxpress.org/html/reproducible-research.html.

CanvasXpress also includes a standalone unobtrusive data table and a filtering widget to allow data exploration and filtering similar to those only seen in high-end commercial tools. Data can be easily sorted, grouped by multiple levels, segregated, transposed, transformed or clustered dynamically. The fully customizable mouse events as well as

the zooming, panning and drag-n-drop capabilities are features that make this library capable of further expansion of functionalities.

CanvasXpress is a standalone JavaScript library that works in all modern browsers on mobile, tablets and desktop devices. The following example shows the basic usage which consists of four elements: the JavaScript and the CSS framework in the <head> section; the data also in the <head>; a <canvas> element in the <body>; and lastly including a mechanism to instantiate the canvasXpress object which in this example is a call to a function triggered after loading the web page.

```
<html>
 <head>
  <link rel="stylesheet" href="path-to-canvasXpress.css" type="text/css"/>
  <script type="text/javascript" src="path-to-canvasXpress.min.js"></script>
  <script>
   var initPage = function () {
    var data = {"y": {"vars": ["Gene1"],
                 "smps": ["Smp1", "Smp2",  "Smp3"],
                 "data": [[10, 35,88]]
                }};
    var conf = {"graphType": "Bar"};
    var cX = new CanvasXpress("canvasId", data, conf);
   }:
  </script>
 </head>
 <body onload="initPage();">
  <canvas  id="canvasId" width="540" height="540"></canvas>
 </body>
</html>
```

CanvasXpress can be now simply used within R at the console to generate conventional plots, in R-Studio or seamlessly embedded in Shiny web applications. A list of examples of the canvasXpress R library including the mouse events, zooming, and broadcasting capabilities is included in the github package (https://github.com/neuhausi/canvasXpress) under the shiny directory. This R library was created with the htmlwidgets[7] package.

Facilitated by canvasDesigner, the bundled graphics layout tool written in JavaScript, the end user can easily arrange any number of different types of plots in SVG format outputted by canvasXpress or other sources on a HTML page. Each individual plot could be adjusted in size and positioned freely. At last, printing as PDF can generate a high-

resolution multi-panel plot as shown in figure 1, which is a standard option on all modern Internet browsers. This design tool relieves scientists from days if not weeks of struggle of using multiple tools, sometime even programming in R or some scripting languages in order to get job done.

CanvasXpress is the first open source package with unprecedented functionalities that are not even seen in expensive commercial tools. It empowers biologists who don't possess advanced computer skills to perform analysis and generate complex publication-ready figures required by the prestigious journals such as Science, Nature and Cell at ease in the big data era.

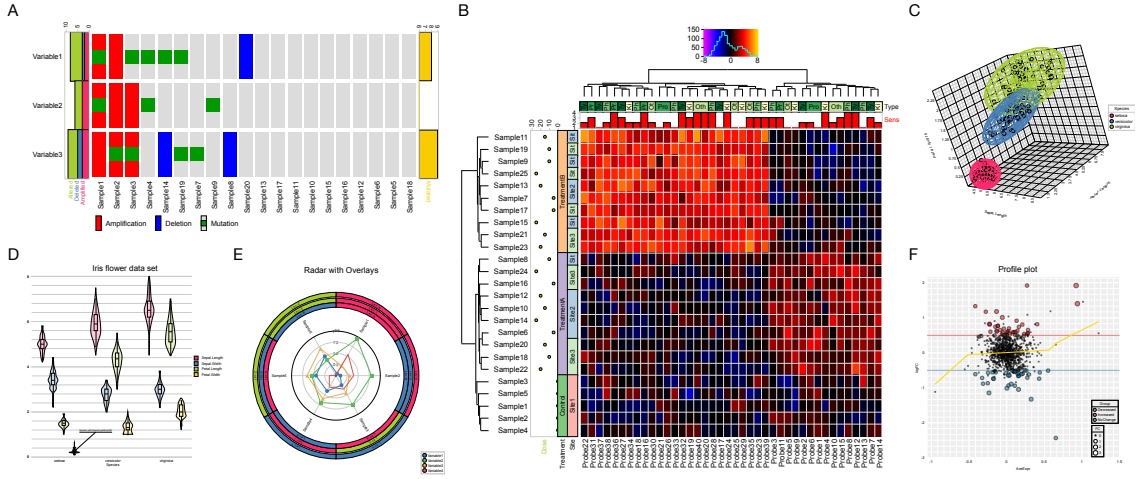

Figure 1. Versatile types of plot generated by canvasXpress. A) Oncoprint of cancer mutations; B) Gene expression heatmap with comprehensive annotations; C) 3D scatter plot; D) Violin plot; E) Spider plot with annotations; F) Profile plot of gene expression.

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7. htmlwidgets for R: https://github.com/ramnathv/htmlwidgets