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Introduction



📣 MathWorks®

- MATLAB is computer software tuned to support the iterative analysis and design process of scientists and engineers.
- You can read more about MATLAB here:
 - <u>https://www.mathworks.com/products/ma</u> <u>tlab.html</u>
 - <u>https://www.mathworks.com/help/matlab/</u>



- Two of the most commonly used MATLAB functions are **plot** and **subplot**.
 - **plot** creates a single data visualization in an output window.
 - **subplot** creates multiple data visualizations in an output window.
- <u>Objective</u>: redesign the **subplot** function to improve user flexibility in customizing layouts.



Example **plot** output



Example *subplot* output





• I utilized the **Double Diamond** framework:







2. Define Issue *Identify target users Identify requirements* **3. Develop Solution** *Prototype iteration Usability Testing*



4. Deliver Solution



Discover Issue









1. Discover Issue *Review customer data*

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4. Deliver Solution





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- An online forum titled 'MATLAB answers' allows customers to ask questions about the product and get feedback from a larger community.
- An analysis of MATLAB answers posts helped us to identify **common questions** that customers had about subplot limitations:

MATLAB Answer Posts	Views in last 30 days
How do I decrease the margins around the subplots in my figure in MATLAB?	1,356
Making less space between figures in subplot	1,070
How to create subplots with little vertical spacing?	795
How to remove subplot grey space between images	580
How to decrease the gap between figures in subplot	230





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- The MATLAB Answers data was used to summarize subplot **pain points**:
 - **PP1**: The default subplot layout leaves a lot of empty space around plots. The empty space could be used to show the data in more detail
 - **PP2**: There is no simple way to adjust the subplot layout spacing and padding
 - **PP3**: There is no simple way to precisely control the subplot layout to create publication quality and graphics and meet publication requirements
 - **PP4**: This is no simple way to create shared decorations (e.g. legend, colorbar, xlabel, ylabel)



Example Pain Points





"No simple way to create shared decorations": It is not currently possible to use subplot to create one legend that is shared between data visualizations as shown above (common layout in research publications)



"Too much empty space around plot": The user would have to use another image editing software to crop subplot spacing before publication









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• In addition to identifying baseline user pain points, MATLAB Answers data was used to research common **roles and goals** for the users experiencing these pain points.



Data Explorer

<u>Goal</u>: Analyze their dataset using multiple plots

Publisher



<u>Goal</u>: Create a high quality plot layout for publication or presentation.





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• The team aligned on 4 high priority **requirements** to address the pain points identified (slide 7), keeping in mind our focus on Data Explorer and Publisher users:

ID	Statement	Pain Point ID (Slide 7)	Priority
1	Reduce the empty space in the default subplot layout, while still providing an aesthetically pleasing display	PP1	Must have
2	Provide a simple way to adjust the padding and spacing in a grid of plots	PP2	Must have
3	Provide a simple way to precisely control layout parameters in a grid of plots	PP3	Must have
4	Provide a way to create a single legend or colorbar for a set of plots	PP4	Nice to have



Develop Solution









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• The following coded prototype for subplot redesign was created by the software developer on my team, taking into consideration the project requirements:



The user would begin by calling the new function, **chartlayout,** in their code and specify the number of rows and columns in their multi-plot grid (e.g. (2,2) for 2 rows, 2 columns). Each consecutive plotting function called would be added to this grid in consecutive order.



Usability Testing: Research Questions

- Can data explorer & publisher users create and tweak the multi-plot layout as desired?
- Are there unknown pain points in the new function design?
 - What is user trying to accomplish? Are we enabling their vision?
 - What level of control is user seeking? Are we meeting this need?
- Does the user find the multi-plot layout of the new design to be aesthetically pleasing?
- Is the chart layout an improvement over subplot? If so, why? by how much?



• Usability Testing: Sample Tasks

Edit the provided MATLAB code so that a new figure is created and this figure displays the layout shown below.



Edit the provided MATLAB code to adjust the layout from Task 1 to match the image below:



• Usability Testing: Sample Tasks



Please use the scale below to rate how you would describe the figures you just viewed.							
1	2	3		4 5	6		7
Not at all			Somewhat Very much				ry much
ITEM		RATING	RATING	ITEM		RATING	RATING
		(Fig1)	(Fig2)			(Fig1)	(Fig2)
Modern				Clunky			
Clean				Confusing			
Understandable				Cluttered	_		
Good layout				Outdated			

Was Figure 1 visually pleasing?





Usability Testing: Key Findings

• Scale presented to participants to gauge difficulty of each task:

Very Difficult		Very Easy				
1	2 □	3 □	4 □	5	6 □	7 □

- ¾ of participants found a *complex task* using the new design was equally or less difficult than a *simple task* using the old design
 - In legend:
 - Subplot = simple task using old design
 - Cl task 1 = simple task using new design
 - Cl task 2 = complex task using new design



Usability Testing: Key Findings

The following qualitative was collected from users about design 'deltas':

- "It would be helpful if the new function had more visual feedback when adding plots to a layout. Example: when you called the new function, it would show an empty grid that fills up with plots as you create them."
- "The [new] features are giving more nuanced control that I might not use"
- "The order in which plots are added to my layout can depend on the order the function is called in my code..this order can vary"



Usability Testing: Key Findings

The following qualitative was collected from users about design 'pluses':

- ✓The proposed design is more **robust** than the old subplot function
- ✓ The old subplot workflow is 'clunky' compared to proposed design
- ✓No need to call proposed functions multiple times to create new layouts like the old subplot
- ✓ Pleasantly surprised by the ability to move legend within the layout in the new design



Deliver Solution





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- After making a couple tweaks to address user 'deltas', the new function was approved by internal reviewers and shipped in MATLAB version R2019b on September 12, 2019.
 - The documentation page can be found here: <u>https://www.mathworks.com/help/matlab/ref/tiledlayout.html</u>
- It has been recognized as 'Pick of the Week' on the File Exchange Blog:
 - Read more here: <u>https://blogs.mathworks.com/pick/2019/09/13/tiled-layout/</u>





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