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Documentation for plotWellTrajectory Solution (Group 04)

Project Title: Hitting the targets

Course Title: Drilling methods I

Course Code: PGG 317

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Group Number: 04

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1. Introduction

- The **plotWellTrajectory** solution is a MATLAB program that enables users to visualize and optimize the **drilling path** of a well that passes through specified **pay zones**. This tool is particularly useful in **drilling engineering** to determine the optimal sequence for reaching multiple pay zones, as well as visualizing both the **3D well trajectory** and the geometry of the pay zones in **2D and 3D**.
- The project was developed with the following objectives:

1. To facilitate the **visual representation** of a well's trajectory through multiple target reservoirs.
2. To implement **optimization algorithm** to minimize the total well path length(Total distance traveled).
3. To provide a **data export feature** that allows users to save trajectory information (MIANET data)in an Excel file for further analysis.

Key Features:

- **3D Trajectory Visualization** with labeled pay zones.
- **Optimization of Pay Zone Order** to minimize drilling distance.
- **Interactive 2D Visualization** for a top-down view of the well trajectory.
- **Excel Export** for saving detailed drilling information.

2. System Requirements and Setup

System Requirements:

- **MATLAB R2020a** or later.
- **Optimization Toolbox** (optional): Required to enable optimal pay zone sequencing.

Dependencies:

- Uses MATLAB built-in functions like spline (for path calculation), smoothdata (for smoothing path data), etc.
- The **Optimization Toolbox** is optional but if enabled with produce best functionality.
- Make sure file named as follows "plotWellTrajectory.m". This is to prevent naming convention error

Installation:

Option 1 Google Drive Link:

- Entirety of solution and other deliverables including video presentation and power point presentation will be submitted on or before 20/11/2024.

Option 2 Open GitHub repository:

- Clone git hub repository into desired directory
- Add path to MATLAB path or move into desired directory to use solution

3. Inputs for plotWellTrajectory Function

Required Inputs

- The function plotWellTrajectory requires the following inputs to generate the trajectory and visuals:

1. Surface Location:
    - **Type**: Array [Northing, Easting, True Vertical Depth].
    - **Description**: This represents the **starting point** of the wellbore, generally at the surface level.

Example:

```
surfaceLocation = [100, 200, 0]; % Northing = 100,Easting = 200,True Vertical Depth = 0 (surface level).
```

2. Pay Zones:
    - **Type**: Cell array containing [N x 6] elements, where N represents the number of pay zones.
    - **Description**: Each pay zone is defined by a set of boundary coordinates, [Northing_start, Northing_end, Easting_start, Easting_end, TVD_start, TVD_end].

Example:

```
payZonePositions = { [500, 600, 400, 500, 600, 800];% Define boundaries for PayZone1
                     [550, 750, 600, 700, 800, 1000];% Define boundaries for PayZone2
                   };
```

3. Pay Zone Shapes:

- **Type**: Cell array of strings.
- **Options**: 'Cylindrical', 'Cuboid', 'Spherical'.
- **Description**: Defines the **shape of each pay zone**, which will be used for plotting and visualization.

Example:

```
payZoneShapes = {'Cylindrical', 'Cuboid'};
```

4. Kick-Off Point Depth (KOP):

- **Type**: Scalar (double).
- **Description**: Defines the **depth at which the wellbore starts deviating** from a vertical path. Typically, this is set at a point where the drill needs to begin its curve towards a specific target.

Example:

```
kopDepth = 300; % Kick-off depth at 300 meters.
```

5. Interval:

- **Type**: Scalar (double).
- **Description**: Defines the **step size** for calculating points along the well path. Smaller values yield more **detailed and smoother paths**, while larger intervals result in faster calculations.

Example:

```
interval = 10; % Calculate points every 10 meters.
```

Optional Arguments:

- 'singleColor': Plot the well path using a **single color** rather than different colors for different segments.
- 'plot2D': Generate a **2D projection** of the well trajectory for an alternative top-down view.
- 'saveExcel': Save the computed data, including **measured depth, inclination, azimuth**, etc., to an **Excel file**.

4. Step-by-Step Usage

Step 1: Defining Inputs

- You start by defining the **surface location**, **pay zones**, **shapes**, **kick-off point**, and **interval** as mentioned above.

Step 2: Calling the Function

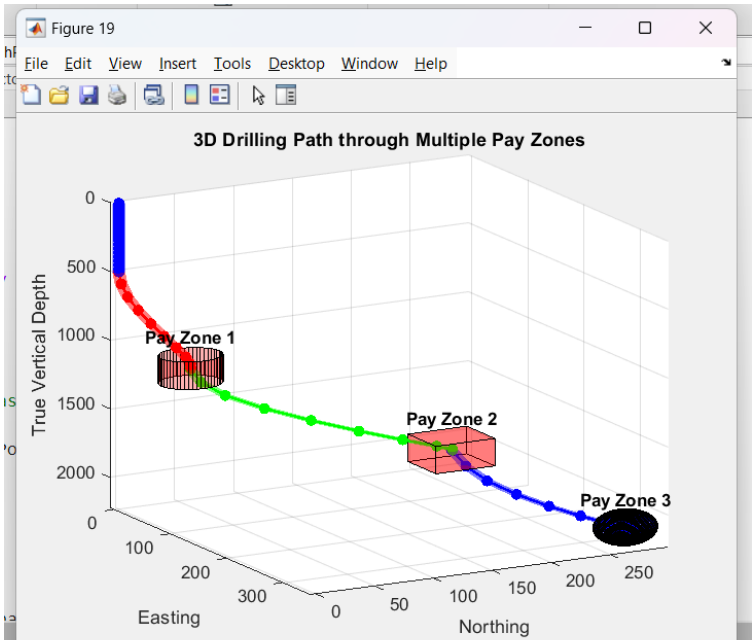
- Below is an example call to plotWellTrajectory with all required and optional parameters:

```
surfaceLocation = [100, 200, 0];
payZonePositions = { [500, 600, 400, 500, 600, 800];
                     [550, 750, 600, 700, 800, 1000]; };
payZoneShapes = {'Cylindrical', 'Cuboid'};
kopDepth = 300; interval = 10;
% Call the function to generate the well trajectory
[M, I, A, N, E, T, MIANETTable] = plotWellTrajectory(surfaceLocation, payZonePositions,
payZoneShapes, kopDepth, interval, 'singleColor', 'plot2D', 'saveExcel');
```

5. Outputs

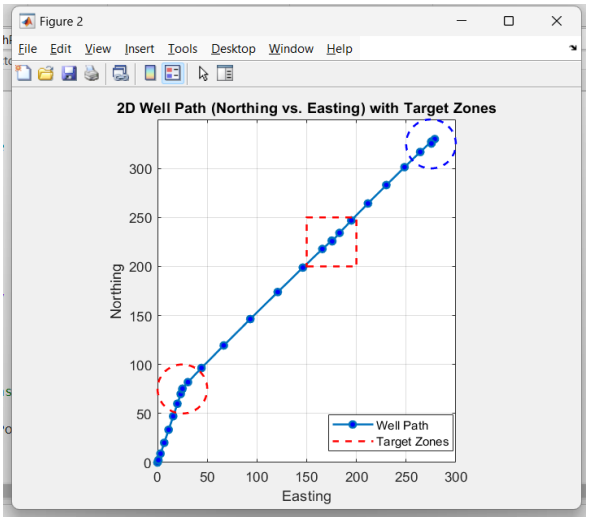
3D Plot

- The **3D plot** shows the well trajectory from the surface to the **pay zones**, illustrating the sequence in which the zones are reached.
- Segments of the trajectory can be colored differently or uniformly, based on user preference.



2D Plot (Optional)

- If the 'plot2D' option is used, a **top-down view** of the trajectory is generated. This 2D representation can help understand the lateral deviation of the path.



Excel File (Optional)

- If the 'saveExcel' argument is used, an Excel file (MIANETTable.xlsx) is generated. This file contains:
  - **Measured Depth**: The cumulative length drilled.
  - **Inclination** and **Azimuth**: Indicate the orientation of the well path.
  - **Northing, Easting, True Vertical Depth**: Coordinates of the path.

6. Explanation of Key Parts in the Code

1. Path Initialization

- **Function**: initializePath(surfaceLocation)
- **Description**: Sets up initial parameters like measured depth (MD), inclination (I), azimuth (A), and coordinates (N, E, T) from the surface location.

2. Transition to Kick-Off Point

- **Function**: moveToKOPAndCalculatePath()
- **Explanation**: Moves vertically to the **kick-off point** depth (KOP), where deviation begins.

3. Calculation of Path to Pay Zones

- **Function**: calculateCurvedPath(...)

- **Details**: After reaching the KOP, this function generates the **curved paths** to reach each of the pay zones.
- **Optimization Step**: If the **Optimization Toolbox** is available, an optimal pay zone sequence is calculated.

4. Optimization of Pay Zone Sequence

- **Function**: optimizePayZoneOrder(payZonePositions)
- **Purpose**: Determines the optimal sequence to visit pay zones, minimizing the total path length.
- **How It Works**:
    - **Distance Calculation**: Computes the distances between the surface location and each pay zone, and then between pay zones.
    - **Sequence Optimization**: Uses a nearest-neighbor heuristic to determine the closest pay zone to visit at each step.
- **Optimization Step**:
    - If the **MATLAB Optimization Toolbox** is available, the optimal sequence is calculated to minimize the total travel distance.
    - **Fallback Scenario**: If the toolbox is not available, the function proceeds in the default pay zone order and displays a warning message.

4. Plotting and Coating

- **Function**: plotSegmentWithColor(...)
- **Explanation**: Plots each segment in either a uniform or varied color scheme. Adds a **cylindrical coating** around the trajectory for better visualization.

5. Excel Data Export

- **Function**: saveMIANETTableToExcel()
- **Details**: Saves the computed values to an **Excel file** for easy reference and further analysis.

7. Contact for Support

- For questions or support regarding the use of this tool, please contact:
- LinkedIn Profile:
  1. **Project Manager**: https://www.linkedin.com/in/israel-adebisi-adesanwo-116463217
  2. **Software Developer:** http://www.linkedin.com/in/damisola-da33355236
  3. **Quality Control Officer**: https://www.linkedin.com/in/afolasewa-ahmed-58a079255
  4. **Technical Expert**:

8. Appendices

Appendix A: Glossary

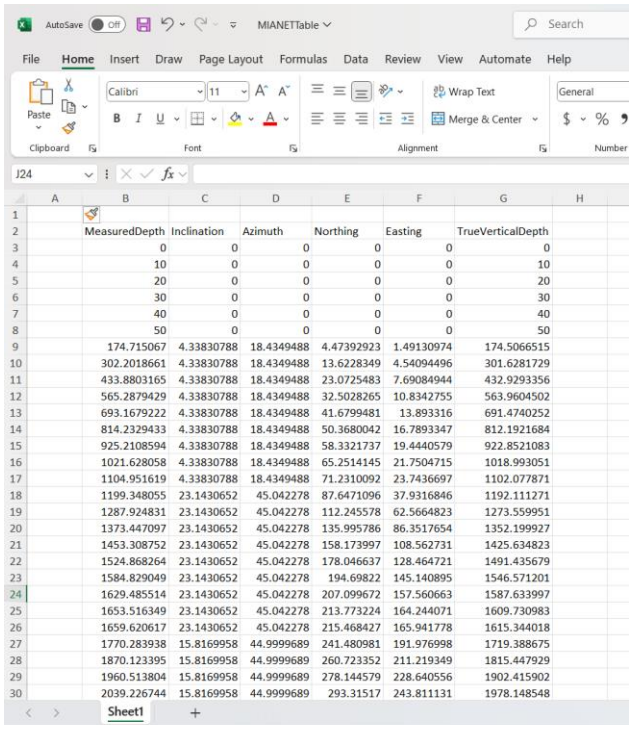
- **Measured Depth (MD)**: The actual distance along the well path.
- **True Vertical Depth (TVD)**: The vertical distance from the surface.
- **Kick-Off Point (KOP)**: The point where the well deviates from the vertical.

Appendix B: Example Outputs

- **MIANET Table**

MeasuredDepth	Inclination	Azimuth	Northing	Easting	TrueVerticalDepth
0	0	0	0	0	0
10	0	0	0	0	10
20	0	0	0	0	20
30	0	0	0	0	30
40	0	0	0	0	40
50	0	0	0	0	50
174.72	4.3383	18.435	4.4739	1.4913	174.51
302.2	4.3383	18.435	13.623	4.5409	301.63
433.88	4.3383	18.435	23.073	7.6908	432.93
565.29	4.3383	18.435	32.503	10.834	563.96
693.17	4.3383	18.435	41.68	13.893	691.47
814.23	4.3383	18.435	50.368	16.789	812.19
925.21	4.3383	18.435	58.332	19.444	922.85
1021.6	4.3383	18.435	65.251	21.75	1019
1105	4.3383	18.435	71.231	23.744	1102.1
1199.3	23.143	45.042	87.647	37.932	1192.1
1287.9	23.143	45.042	112.25	62.566	1273.6
1373.4	23.143	45.042	136	86.352	1352.2
1453.3	23.143	45.042	158.17	108.56	1425.6
1524.9	23.143	45.042	178.05	128.46	1491.4
1584.8	23.143	45.042	194.7	145.14	1546.6
1629.5	23.143	45.042	207.1	157.56	1587.6
1653.5	23.143	45.042	213.77	164.24	1609.7
1659.6	23.143	45.042	215.47	165.94	1615.3
1770.3	15.817	45	241.48	191.98	1719.4
1870.1	15.817	45	260.72	211.22	1815.4

- Excel Spreadsheet



	MeasuredDepth	Inclination	Azimuth	Northing	Easting	TrueVerticalDepth
1	0	0	0	0	0	0
2	10	0	0	0	0	10
3	20	0	0	0	0	20
4	30	0	0	0	0	30
5	40	0	0	0	0	40
6	50	0	0	0	0	50
7	174.715067	4.33830788	18.4349488	4.47392923	1.49130974	174.5066515
8	302.2018661	4.33830788	18.4349488	13.6228349	4.54094496	301.6281729
9	433.8803165	4.33830788	18.4349488	23.0725483	7.69084944	432.9293356
10	565.2879429	4.33830788	18.4349488	32.5028265	10.8342755	563.9604502
11	693.1679222	4.33830788	18.4349488	41.6799481	13.893316	691.4740252
12	814.2329433	4.33830788	18.4349488	50.3680042	16.7893347	812.1921684
13	925.2108594	4.33830788	18.4349488	58.3321737	19.4440579	922.8521083
14	1021.628058	4.33830788	18.4349488	65.2514145	21.7504715	1018.993051
15	1104.951619	4.33830788	18.4349488	71.2310092	23.7436697	1102.077871
16	1199.348055	23.1430652	45.042278	87.6471096	37.9316846	1192.111271
17	1287.924831	23.1430652	45.042278	112.245578	62.5664823	1273.559951
18	1373.447097	23.1430652	45.042278	135.995786	86.3517654	1352.199927
19	1453.308752	23.1430652	45.042278	158.173997	108.562731	1425.634823
20	1524.868264	23.1430652	45.042278	178.046637	128.464721	1491.435679
21	1584.829049	23.1430652	45.042278	194.69822	145.140895	1546.571201
22	1629.485514	23.1430652	45.042278	207.099672	157.560663	1587.633997
23	1653.516349	23.1430652	45.042278	213.773224	164.244071	1609.730983
24	1659.620617	23.1430652	45.042278	215.468427	165.941778	1615.344018
25	1770.283938	15.8169958	44.9999689	241.480981	191.976998	1719.388675
26	1870.123395	15.8169958	44.9999689	260.723352	211.219349	1815.447929
27	1960.513804	15.8169958	44.9999689	278.144579	228.640556	1902.415902
28	2039.226744	15.8169958	44.9999689	293.31517	243.811131	1978.148548

Final Notes:

- The development of this project has been a highly enriching experience for the entire team. We gained significant insights into well path optimization, data visualization, and problem-solving.
- We sincerely hope that this tool proves useful for educational purposes and helps in understanding well trajectory visualization.
- We are open to any feedback, which would help us improve the project further and refine our skills.
- Feel free to reach out for further clarifications or improvements. Your input is invaluable to us, and we are eager to learn from your perspective.