

Introduction and Background

Studies analyzing branching in CAD have identified the existence of distinct patterns and use cases of branching based on designer feedback and comments.

This study analyzes a year's worth of audit trail data from a design firm to identify the empirical characteristics of branching in CAD and propose improvements to branching functionality and workflows.

Branch

- A branch is a clone of a CAD file that can be edited independently of the original file (root branch)
- In Onshape, a branch is a clone of a workspace version

Merge

- A merge is the integration of a branched CAD file into a target branch
- In Onshape, a merge integrates all changes from the selected workspace into the target branch

We propose that branching tools in CAD require functionality and workflow improvements to permit wider use in professional design contexts.

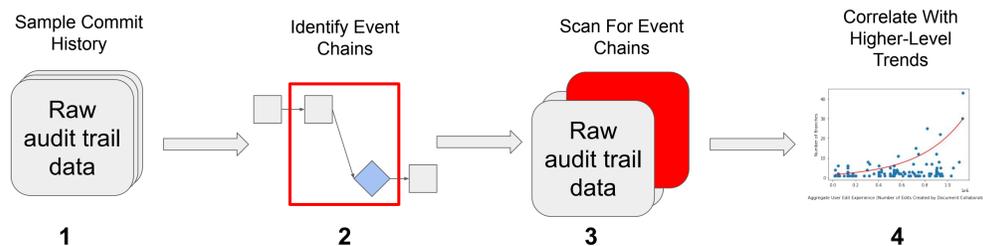
Objectives

1. **Empirically** identify how branching is used in design workflows by:
 - a. Identifying the **frequency** and **intention** of CAD branching use cases
 - b. Investigating the correlation of **descriptive document statistics** with the number and type of branch created
2. Identify **shortcomings** of branching functionality and strategy in CAD
3. Provide **recommendations** for branching functionality and strategy in CAD

Descriptive document statistics: Design size, number of contributors, designer level of experience, number and type of all events

Experimental Methods

Onshape audit trails consist of series of labelled events (actions performed by user in a workspace), without dimensional or model content-specific information.



1. Sample document commit history from raw audit trail data
2. Identify event chains corresponding to branching use case
3. Scan audit trail for branching event chains and tabulate
4. Correlate branching event chains with descriptive document statistics

Use Case Event Chains

List of use cases is selected from Cheng 2022¹, use cases that can be positively identified without design-contextual information (CAD model identity and purpose) are selected for analysis

- Maintain Production Version
 - Branch with no subsequent merge
 - Fix Errors or Experimentation Merge
 - Branch with subsequent merge
 - Experimentation
 - Number of versions created from a branch greater than 3
 - Configuration
 - Configuration event in audit trail
- (Not performed using branching, but analyzed for purposes of comparison)

High-Level Statistics

Event Type	Number of Events	Number of Documents Containing Event Instance	% of Total Events	% of Total Documents
All	1510412	4269	-	-
Branch	464	144	0.03%	3.37%
Merge	186	49	0.01%	1.15%
Version Creation	7506	1129	0.50%	26.45%
Design Edit	1135304	2216	75.17%	51.91%

Table 1: High-level statistics for raw Onshape audit trail data

- 16 total contributors across all documents, 12 of which create branches
- Most frequent branching time is within first third of model history
- A majority of branches are edited only by the user who created the branch

Branching Event / User Statistics

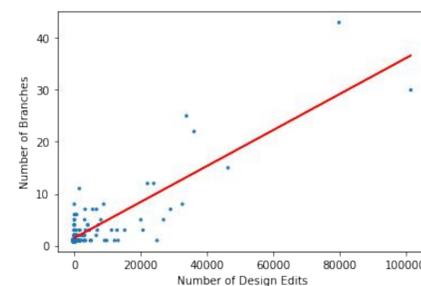


Chart 1: Number of Branches Versus Number of Design Edit Events

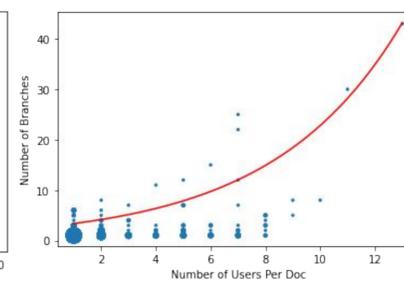
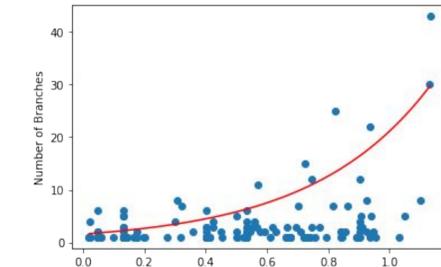


Chart 2: Number of Branches Versus Number of Collaborators Per Doc



(Left) Chart 3: Number of Branches Versus Aggregate User Edit Experience

Aggregate User Edit Experience (Number of Edits Created by Document Collaborators)

Branching Use Case Statistics

Use Case Type	Number of Use Case Instances	Number of Documents Containing Use Case	% of Total Documents
Maintain Production Version	328	144	3.37%
Fix Errors or Experimentation Merge	136	49	1.15%
Experimentation	222	104	2.44%
Configurations	413	78	1.83%

Table 2: Statistics for branching use cases identified in audit trail

Key Findings

Correlations With Descriptive Statistics

- Branching and merging functionality is used in a **minority** of CAD files
- Document complexity number of document collaborators, and collaborator experience are **positively correlated** with greater branching usage

Frequency and Intention of Branching Use Cases

- Branching use case of Maintain Production Version, relating to management of the main branch, is the most common use case identified, **supporting similar findings** in Cheng 2022
- Branches are generally created to **serve an individual designer's workflow**, or a small number of users rather than wider collaboration

Shortcomings of Branching Functionality and Strategy in CAD

- Branching is performed more often by individuals to support **individual workflows**, rather than to support collaboration
- Merging changes in CAD **difficult** and practiced rarely

Recommendations

- To allow for better merging, add ability to **selectively branch/merge** subsections of parts
- Provide comprehensive **designer training** on use cases of branching in CAD, specifically for collaboration

Future Work

Obtain larger data set, from different companies

Analyze CAD data in-context (measurements included)

Interview users to obtain use case intention ground truth

Investigate audit trails of different platforms

1. (Under Review) Cheng, K. 2022. "How does Computer-Aided Design branch out to Git? An analysis of CAD branching from online user forums".