# Feature interactions

# Example: banner selection

| ... | category_ad | category_site | ... | is_clicked |
|---|---|---|---|---|
| ... | auto_part | game_news | ... | 0 |
| ... | music_tickets | music_news | .. | 1 |
| ... | mobile_phones | auto_blog | ... | 0 |

# Example: banner selection

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| ... | auto_part | game_news | ... | 0 |
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| ... | mobile_phones | auto_blog | ... | 0 |

| ... | ad_site | ... | is_clicked |
|---|---|---|---|
| ... | auto_part\|game_news | ... | 0 |
| ... | music_tikets\|music_news | .. | 1 |
| ... | mobile_phones\|auto_blog | ... | 0 |

# Example of interactions

| f1 | f2 |
|---|---|
| A | X |
| B | Y |
| B | Z |
| A | Z |

# Example of interactions

| f1 | f2 |
|---|---|
| A | X |
| B | Y |
| B | Z |
| A | Z |

Join

<table>
<tr><th>f_join</th></tr>
<tr><td>A|X</td></tr>
<tr><td>B|Y</td></tr>
<tr><td>B|Z</td></tr>
<tr><td>A|Z</td></tr>
</table>

OneHot
(f_join)

<table>
<tr><th>A|X</th><th>B|Y</th><th>B|Z</th><th>A|Z</th></tr>
<tr><td>1</td><td></td><td></td><td></td></tr>
<tr><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td></td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>1</td></tr>
</table>

# Example of interactions

| f1 | f2 |
|---|---|
| A | X |
| B | Y |
| B | Z |
| A | Z |

OneHot(f1),
OneHot(f2)

| A | B |
|---|---|
| 1 | |
| | 1 |
| | 1 |
| 1 | |

| X | Y | Z |
|---|---|---|
| 1 | | |
| | 1 | |
| | | 1 |
| | | 1 |

Pairwise columns
multiplications

| AX | AY | AZ | BX | BY | BZ |
|---|---|---|---|---|---|
| 1 | | | | | |
| | | | | 1 | |
| | | | | | 1 |
| | | 1 | | | |

# Example of interactions

| f1 | f2 |
|---|---|
| 1.2 | 0.0 |
| 3.4 | 0.1 |
| 5.6 | 1.0 |
| 7.8 | -1.0 |

$\xrightarrow{\text{Mul}}$

| f_join |
|---|
| 0.0 |
| 0.34 |
| 5.6 |
| -7.8 |

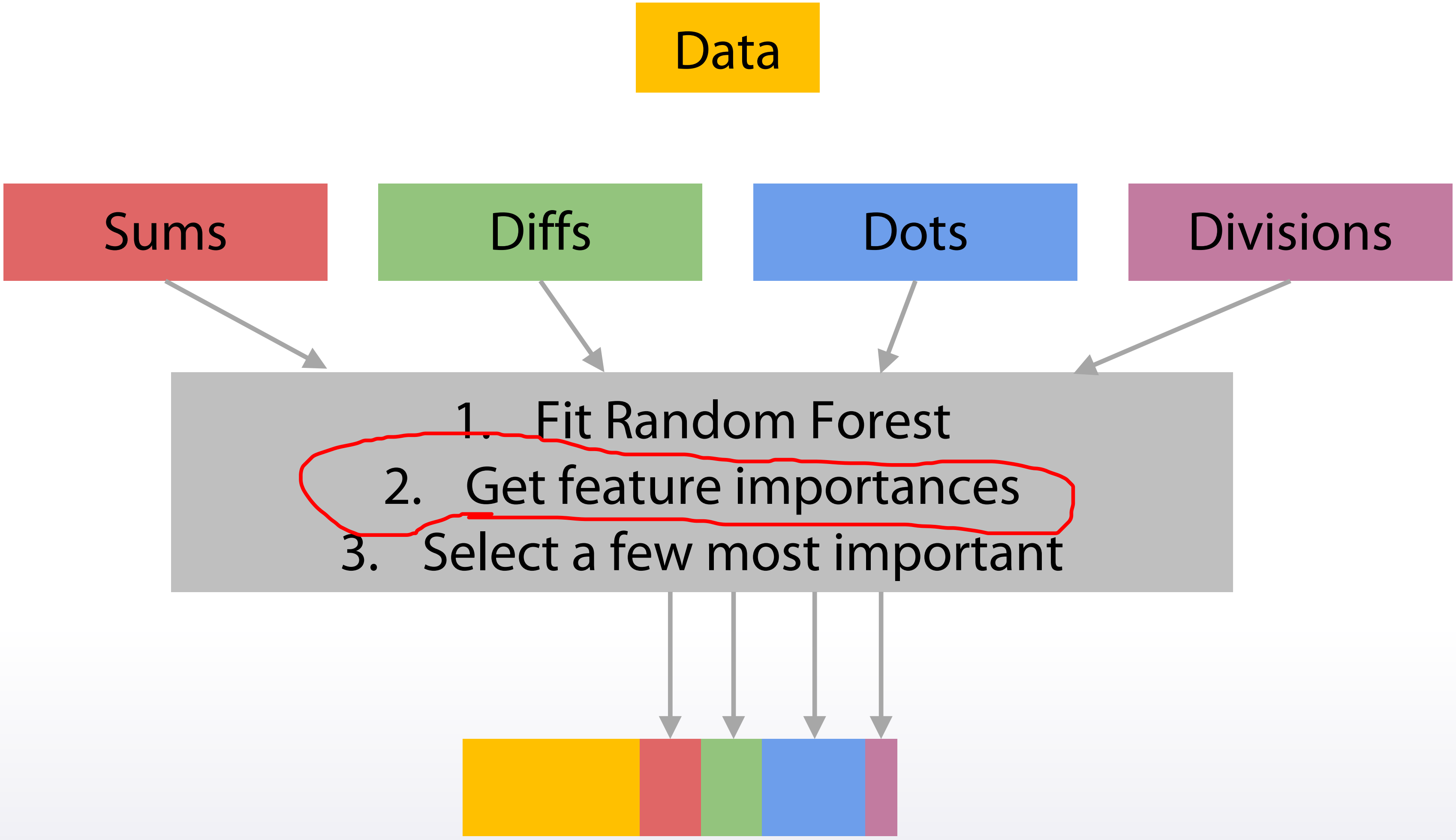
# Frequent operations for feature interaction

- Multiplication
- Sum
- Diff
- Division

# Practical Notes

- We have a lot of possible interactions – N*N for N features.
    a. Even more if use several types in interactions
- Need to reduce its’ number
    a. Dimensionality reduction
    b. Feature selection

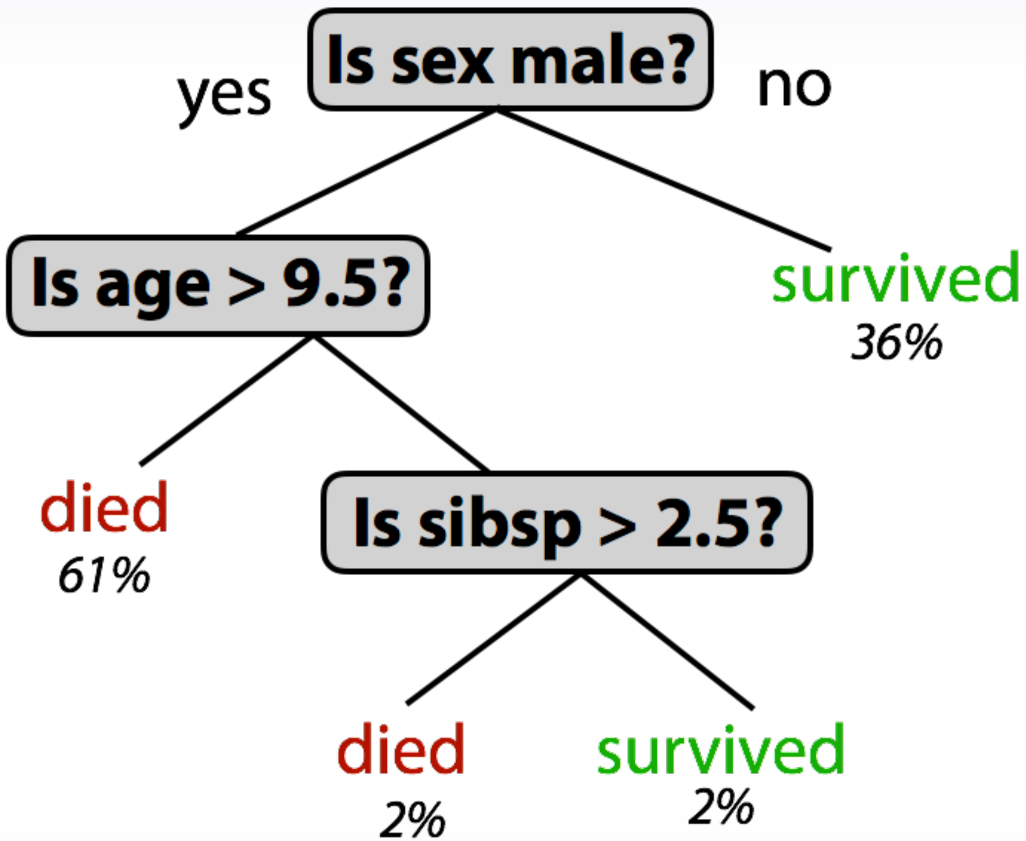
# Example of interaction generation pipeline



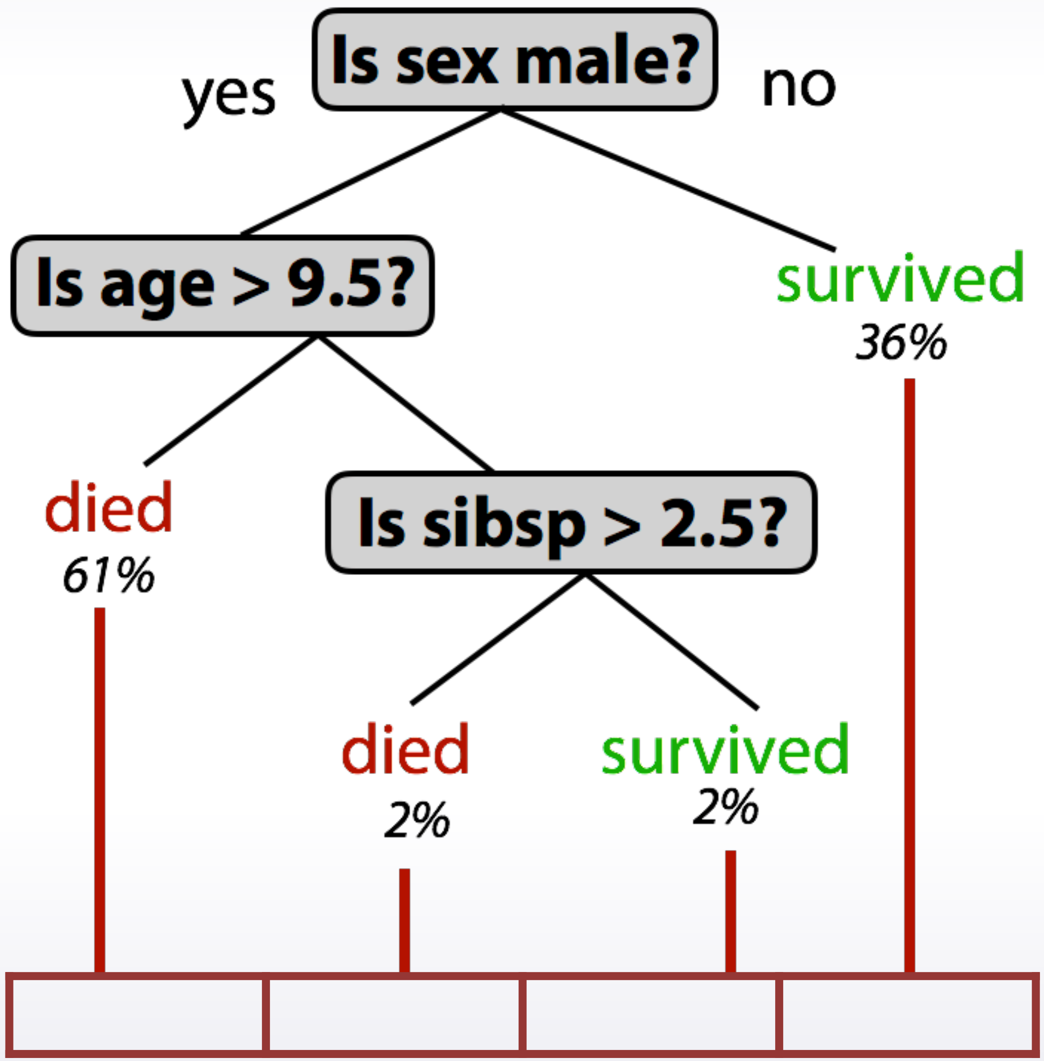
# Interactions’ order

- We looked at 2nd order interactions.
- Such approach can be generalized for higher orders.
- It is hard to do generation and selection automatically.
- Manual building of high-order interactions is some kind of art.

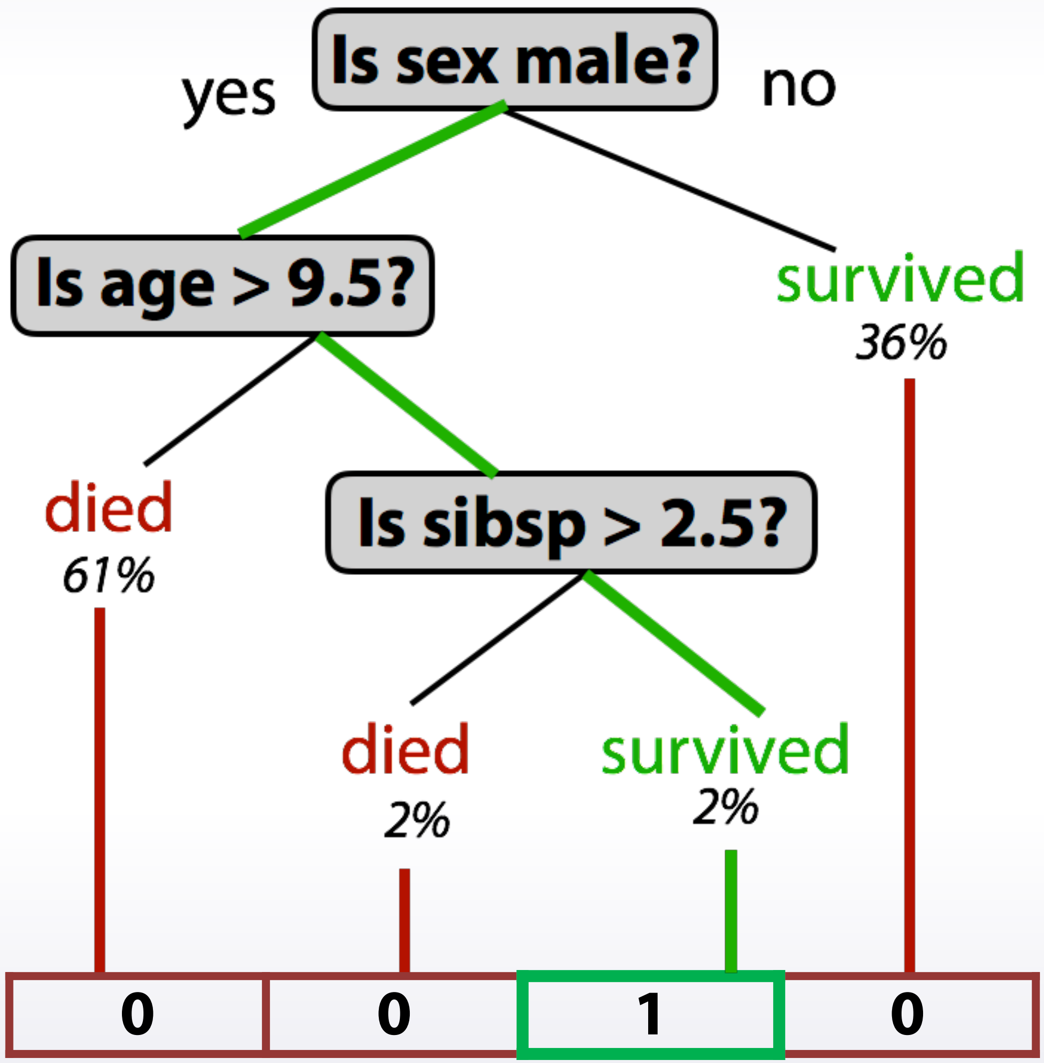
# Extract features from DT



# Extract features from DT



# Extract features from DT



# How to use it

In sklearn:

```
tree_model.apply()
```

In xgboost:

```
booster.predict(pred_leaf=True)
```

# Conclusion

- We looked at ways to build an interaction of categorical attributes
- Extended this approach to real-valued features
- Learn how to extract features via decision trees