

Effective Float Strategies

Frank Mittelbach

Introduction Visualization Adding Floats Results

The End

Effective Float Strategies DocEng Conference 2017, Malta

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LATEX3 Project



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What's this all about ...

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Introduction

Visualization Adding Floats Results Comparisons The End

Pagination with floats

- Last year's starting point
- Visualizing the general approach
- Adding floats to the mix
- Results
- Comparisons



John Tenniel, 1870



Last year's starting point

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Introduction

Visualization Adding Floats Results Comparisons The End Pagination with greedy algorithm fails for nearly 100% of the cases

Idea: use dynamic programming approach (e.g., Knuth/Plass) for pagination

Doable ... Complexity is

- O(n) for fixed spread structure
- $O(n^2)$ otherwise

But . . .

- there is not enough flexibility in a page
- Thus: most of the time optimizing runs out of options

- spread height variations (run them long or short)
- paragraph variations (format to different heights)



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- Add enough flexibility ... through
 - spread height variations (run them long or short)
 - paragraph variations (format to different heights)



The battlefield A visualization of the algorithm

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John Tenniel, 1870



The Basics



The galley in need of pagination

- Blue bars represent (blocks of) lines
- Breaks happen only between blocks
- Above we mark candidate breaks (active nodes) in red



he Basics



Active nodes

- Sliding window into the document
- Add new node when breakpoint can end a page
- Only the best solution (accumulated costs) is used
- Deactivate when too far from current point











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The End	too close
	Step
	 Loop through breakpoints and try to make a page











The basics



Loop through breakpoints and try to make a page ...































The basics



► Try next active node (fail) ...


































































Complexity



Complexity

- ► Loop through all *n* breakpoints
 - and try making pages back to each active node
- Thus the complexity is
 - $O(n \times \langle \text{average length of active list} \rangle)$



Pages have identical heights



active nodes for different pages may get close together











































































Pages have different heights



▶ as we will have more active nodes to deal with ...


















































































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Pages have identical heights (after some page)

- Active list is bounded by a constant
- Thus
 - $O(n \times \langle \text{average length of active list} \rangle) = O(n)$

Pages have varying heights

- ► Active list can grow arbitrarily (i.e., *O*(*n*))
 - Thus we end up with
 - ► $O(n \times \langle \text{average length of active list} \rangle) = O(n^2)$

Spread and paragraph variations

- They add a factor of O(1) to the length of the active list
- Thus the complexity doesn't change!



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Visualization Adding Floats

Results

The End



John Tenniel, 1870



A visualization



We extend the algorithm at the point where we ...

• ... add active nodes for a new spread (here page 3)



A visualization





A visualization





A visualization





A visualization



Now we prepare float placements for the next spread

• ... this is for the case without floats





Now we prepare float placements for the next spread

• ... and for each layout with floats add another node





Now we prepare float placements for the next spread

which may have extra costs associated ...



700+... Effective Float Strategies 3 ÷ 700+B 3 float placement B 700+A 3 float placement A Adding Floats 660 580 700 $_3$ no floats \mathbf{b} too far away

Step

• ... then we continue looping ...



700+... Effective Float Strategies 3 ÷ 700+B 3 float placement B 700+A 3 float placement A Adding Floats 580 700 $_3$ no floats 2 2 too far away

Step

• ... then we continue looping ...



700+... Effective Float Strategies 3 ÷ 700+B 3 float placement B 700+A 3 float placement A Adding Floats 700 580 $_3$ no floats 2 2

Step ► ... and so on and so forth ...



Main points

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When ending a spread

- Add new active nodes for each candidate placement
- Add "costs" in case the placement involves a preference rule that can be determined at this point (e.g., some float regions are preferred over other)

When seeing a call-out

- Check if any call-out/float relation is violated and if so deactivate the corresponding active node
- If a call-out/float preference rule is triggered we add the corresponding costs to the active node

When attempting to make a page (or column)



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Precompute candidate float placements

(whenever a spread has ended)

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Nithout any restricting rules (the bad case)

- We know which floats have already been placed
 - There is only a limited amount of space available
- But beyond that: We know nothing!

- ▶ Number of placements is $O(n^c)$ for some constant c > 1
 - *c* is roughly the average the number of floats that can be placed on a spread



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Without any restricting rules (the bad case)

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Important facts resulting from the above

- ▶ Number of placements is $O(n^c)$ for some constant c > 1
 - *c* is roughly the average the number of floats that can be placed on a spread

So this will get unmanageable fast!




Different types of rules

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Rule types

- Absolute rules: placement not allowed if violated
- Preference rules: placement is (un)favorable

- Floats are placed in order of their first/main call-out
 - Different streams are (usually) independent
- A float must appear after its call-out ...
 - same or later column (usual approach)
 - strictly after (fairly restrictive)
 - same page or spread or later (difficult with greedy algorithms; involves reiormatting)
 - must be placed in their subsection (dangerous)
 must be visible from the call-out (very dangerous)



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Different types of rules, continued

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Column, page, spread related constraints

Number of floats

- Example: no more than *x* floats on top of column
- Example: no more than y floats on spread
- Example: more than one float per page is discouraged

Area sizing

- Example: minimum of *x*% of text required
- Example: bottom area must be smaller than ...

- Example: only top or bottom area can be used
- Example: Adjacent areas need visually compatible floats



Different types of rules, continued

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whenever a spread has ended)

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Floats are sequenced (the better case)

- We know which floats are next in sequence
- ▶ There is only a limited amount of space available
- We know if a call-out for a float can appear on the next spread

- Number of placements is bounded by a constant
- Placements can be computed in linear time (and fast)



whenever a spread has ended)

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Assumptions

- Floats are placed sequentially
- Different float streams are independent
- Relation between # of floats and the document length is linear

The length of the active list

- First float on the next spread may be any of the floats (i.e., the possibilities are equal to # of floats)
- Number of different candidate solutions with the first float fixed is bounded by a constant

- $O(n^{\text{# of float streams}+1})$ if the page height is fixed
- $O(n^{\# \text{ of float streams}+2})$ otherwise



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The overall complexity — Anything non-linear is bad news

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Apply pruning

- Require that floats stay close to their call-out:
 - Candidate solutions that require too many
 - page-turns are dropped
 - placed earlier)

s this adequate?

- Yes: Users expect to see a float close to its call-out
- Unnecessary page-turns reduce reading experience



The overall complexity — Anything non-linear is bad news

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John Tenniel, 1870

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Length of the active list

- First float on next spread must have its call-out close by
- Thus, the number of different possibilities for the first float is bounded by a constant
- Thus, the factor by which the active list can increase is bounded by a constant

- ▶ *O*(*n*) if the page height is fixed
- $O(n^2)$ otherwise



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- Thus, the factor by which the active list can increase is bounded by a constant

- ▶ *O*(*n*) if the page height is fixed
- $O(n^2)$ otherwise



Effective Float Strategies

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Length of the active list

- First float on next spread must have its call-out close by
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- Thus, the number of different possibilities for the first float is bounded by a constant
- Thus, the factor by which the active list can increase is bounded by a constant

The overall complexity drops back to

- ► *O*(*n*) if the page height is fixed
- $O(n^2)$ otherwise

... which is where we want it to be





Time and space ... or what happens in real lif

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John Tenniel, 1870

"Well, in OUR country," said Alice, still panting a little, "you'd generally get to somewhere else—if you ran very fast for a long time, as we've been doing."

"A slow sort of country!" said the Queen. "Now, HERE, you see, it takes all the running YOU can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"



The chosen challenge

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John Tenniel, 1870

Through the Looking Glass

- A galley with 2516 breakpoints
- 47 pictures to place

The ask

- Layout with 46 lines per column
- No orphans and widows!
- Maximum of one figure per column
- Favor solutions with sections at column top



Trial results with standard LATEX (i.e., greedy algorithm)

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Always enforced / preferred

- No widows and orphans
- Minimum of 2 text lines after a heading
- Encourage headings at top of columns

Running time: less than 2 seconds Results:

- 98 text columns
 - ▶ 55 good columns (badness < 4000)
 - 1 horrible column (badness 6559)
 - 34 infinitly bad columns
- 5 half-empty float columns
- Only 1 heading at top of column (out of 9)

Estimated time for fixing: $(35 + 5) \times 15 \min \approx 10$ hours



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Trial results with global optimization and no restrictions (other than sequencing)

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Tho End

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Algorithm

Include both paragraph and spread variations



Trial results with global optimization and no restrictions (other than sequencing)

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Algorithm

Include both paragraph and spread variations

More than 10 hours processing time





Trial results with parameterized objective function

Floats and base algorithm and pruning)

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Comparisons

The End

Always enforced / preferred

- No widows and orphans
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Algorithm

- ► Just the base algorithm + floats
- Try pruning after x page turns to shorten time necessary



Trial results with parameterized objective function

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Runs out of options to optimize near the beginning





Trial results with parameterized objective function (Floats and variations and pruning)

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Restricting allowed page-turns

- ► Allow 0, 1, 2, 3, ... turns (per float)
- Costs = expensive / moderate / cheap

Spread length variations

Disallowed / expensive / moderate / cheap

Paragraph length variations (\looseness)

Disallowed / allowed (costs based on paragraph quality)



Trial results with parameterized objective function (Floats and variations and pruning)

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- ▶ Horizontally: apply pruning after 0, 1, 2, ... page turns
- Vertically: page turn costs are expensive / moderate / cheap
- Champagne bottles indicate 8 or 9 sections placed on column top
- Hourglass means this (and later) trials need more than 5 min





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Effective Float Strategies

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Introduction Visualization Adding Float

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The End

Pagination with greedy algorithm still fails for nearly all cases (i.e., floats do not make things better)

Idea: use dynamic programming approach for pagination with extra flexibility and add floats

Doable ... in that case complexity is

- $O(n^{\text{# of float streams}+1})$ if the page height is fixed
- $O(n^{\# \text{ of float streams}+2})$ otherwise

But . . .

- quadratic or cubic growth (or worse) is still too slow
- who wants to wait 10+ hours each run?

- this is reasonable as it fits with user expectations
- and produces results in acceptable time



Effective Float Strategies

Frank Mittelbach



Visualizatior

Adding Floats

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Effective Float Strategies

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Apply pruning ... to cut down the search space

this is reasonable as it fits with user expectations

and produces results in acceptable time!



Comparisons

- Effective Float Strategies
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John Tenniel, 1870



Comparison – spreads 1 + 2





optimal

















Comparison – spreads 3 + 4



























Strategies

Comparison – spreads 5 + 6









Comparison – spreads 7 + 8

greedy viz. optimal, 0 turns





Comparison – spreads 1 + 2











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Comparison – spreads 3 + 4















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Comparison – spreads 5 + 6









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Comparison – spreads 7 + 8

Effective Float Strategies



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Mischief managed!

Effective Float Strategies

Frank Mittelbach

Introduction Visualization Adding Floats Results Comparisons

The End



Hope I was able to reveal something new for you. Thank you!

John Tenniel, 1870