Motivation
The new software
Open problems and future directions

Creating mathematical jigsaw puzzles using T$_E$X and friends

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Outline

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What is a 'Mathematical Jigsaw'?
Existing software
CMEP and its needs

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What is a 'Mathematical Jigsaw'?

- Used in classrooms for variety of purposes:
- Jigsaws and dominoes: A more enjoyable way to practise skills; can involve logical reasoning too
- Card sorts: Sort into groups or into order

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Examples

- Jigsaw (dark blue)
    - Sides match if the question gives the answer
    - A '?' means an answer is not given – you have to work it out
    - The outside edges of the puzzle will not match anything
    - Ignore the small circled numbers
- Card sort (pale blue)
    - Order these to prove that $\sqrt{2}$ is irrational
    - Again ignore the small circled numbers
- Follow-me cards or dominoes (yellow)
    - These form a continuous loop, joining question to answer
    - In a class, each student has some of the cards to read out

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Examples (Answers)

- Jigsaw (dark blue)
    - Printed solution sheet
- Card sort (pale blue)
    - $2 - 5 - 6 - 7 - 9 - 3 - 8 - 4 - 1$
- Follow-me cards or dominoes (yellow)
    - No answers offered!

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Existing software

- Formulator Tarsia
  - Created by Hermitech Laboratory
  - Free (as in beer)
  - Windows-only
  - MathML-based
  - Graphical frontend
  - Very popular in schools in UK
  - Many resources (activities) available to download

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What is CMEP?

- Cambridge Mathematics Education Project
- Creating rich, engaging, coherent mathematics resources for 16–18 year olds
- In development phase
- Public website launch planned for early 2015
- Resources will include card sorts and perhaps jigsaws

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Why not use Formulator Tarsia?

- Windows-based; CMEP developers use Mac or Linux
- I prefer TeX output quality to Tarsia output
- More flexibility and control with TeX
- Tarsia content cannot be easily imported or exported
- Tarsia is semi-WYSIWYG so harder to input than TeX
- Need output in printable form and Markdown for automated conversion to HTML

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Design goals
The implementation

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User needs

- Easy to input content
- Flexibility to have different layouts, fonts, etc.
- Flexibility to easily change format of puzzle
- Preferably text-based input files
- Knowledge of LaTeX can be assumed, but nothing more
- Easy to generate jigsaws, etc., from input files

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Software goals

- Operating-system agnostic (at least Mac & Linux)
- Easy to install and use
- Minimum of non-standard dependencies
- Easy to maintain and extend (time constraints)
- Can produce Markdown output for converting into webpages

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The implementation

- Data input files: YAML
- LaTeX template files: Use Ti*k*Z
- Data structure template files: YAML
- Processing software: Python 3.x, calls (lua)latex to typeset
- In alpha state

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Example data file

- Title and type specification
- Layout specification (overriding defaults)
- Content data

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Example data file: Title and type specification

```
# Proving $\sqrt{2}$ is irrational
type: cardsort
title: $\sqrt{2}$ is irrational
note: Sort the cards into order to prove ...
```

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Example data file: Layout specification

```
# puzzle size
rows: 6
columns: 1
# Do we shuffle the order of the cards from
# the order given when producing the problem?
# Say "true" for a proof sorting activity.
# It probably does not make sense to say
# "false" here but still to produce a solution.
shuffleCards: true
# Does this puzzle require production of a
# solution?  If so, the cards must be given
# in the correct order initially.
produceSolution: true
```

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Example data file: Layout specification

```
# Default text size on cards
textSize: 6
# Card title
cardTitle: CMEP -- $\sqrt{2}$ is irrational
cardTitleSize: 2

# Use CMEP Markdown output
puzzleTemplateMarkdown:
  template-cardsort-puzzle-CMEP-1col.md
solutionTemplateMarkdown:
  template-cardsort-solution-CMEP-1col.md
```

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Example data file: Content data

```
cards:
  – Suppose, for a contradiction, that ...
  – That is, we can write $\sqrt{2} = ...$
  – Squaring, we have $2 = \frac{m^2}{n^2}$.
  – Multiply across to get $2n^2 = m^2$.
  – In the prime factorisations of $m^2$ ...
  – In the prime factorisation of $2n^2$, ...
  – But prime factorisations are unique, so ...
  – This is a contradiction, so our original ...
  – So $\sqrt{2}$ is irrational.
```

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Other niceties

- Can number cards
- Hidden or different puzzle data (e.g., '?' in puzzle)
- Can handle images

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Open problems

- How do I store and locate configurations on different OSes?
  - Standard template files
  - User template files
  - Software to work identically on Mac, Linux and even Windows?
- How do I create a 'package' for each of the different OSes which can be simply installed?

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Future directions

- Write documentation!
- Allow for command-line and configuration file configuration
- If really wanted, create a graphical data editor.
  - But I think text-based file is simpler to edit.

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Obtaining the software

- https:
  //github.com/juliangilbey/jigsaw-generator
- Email me at J.Gilbey@maths.cam.ac.uk or
  jdg@debian.org