IntuiGeo: Interactive tutor for online geometry problems resolution on pen-bases tablets E-Fran Actif project

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Introduction

The 2D recognition engine Construction problem modelling Automated Resolution and interactive supervision Experiments and results Conclusion

Global vision of IntuiGeo: e-learning system for geometry learning

- Online recognition of user's strokes.
- Supervision of resolution strategy in construction problem.
- Visual and corrective feed-back generation.



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CD-CMG formalism [S. Macé, E. Anquetil, 2009]

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- Problematic and design principles
- The problem generation module
- The problem model: the knowledge graph
- 4 Automated Resolution and interactive supervision
 - The learner module
 - The resolution module





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Problematic and design principles The problem generation module The problem model: the knowledge graph

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Challenges

- Automated generation: from the teacher's recognized strokes
- **Supervision**: *of the child resolution* to provide feed-back

IntuiGeo supervision engine components

- **Problem generation module**: synthesis of geometry problem from teacher example;
- Resolution module: synthesis of resolution strategies;
- Learner module: analysis of pupil resolution advancement and feed-back generation.

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Exercise generation from teacher's drawing



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Knowledge graph definition

- Set of nodes and edges such as
- a node n is defined by
 - T: the recognized element from the 2D engine
 - RefC: reflexive constraints on T
 - DefC: Constraints depending on the mathematical definition of T;
- Each edge is denoted by a triple e = (Nf, Ns, Rel) with
 - Nf: the node corresponding to the tail node;
 - Ns: the node corresponding to the head node;
 - Rel: the set of relative constraints linking Ns and Nf.



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Construction of knowledge graph: dependency relations



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Construction of knowledge graph: constraints propagation



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Construction of knowledge graph: structural relations



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Pedagogical elements inclusion and instruction generation

- Pedagogical limitations are extracted from the drawing procedure
- The instruction: the necessary and sufficient knowledge to solve the problem



(a) First type of exercise

• Draw the isosceles triangle ABC of base AB, given AB=3.5cm and AC=4cm



(b) Second type

• Draw the isosceles triangle BAE of base AB, given AB=5cm and EAB=40

The learner module The resolution module

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Graph matching

- Each recognized element is matched with the most likely node in KG
- Corrective feed-back is a description of unsatisfied constraints.
- Need for adaptive guidance feed-back

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The learner module The resolution module

Motivation and principles

- Objective: supervise the child strategy and provide adaptive feed-back
- We reformulate the resolution into a planning problem where:
- the goal: all nodes in KG are in the state completed
- the plan: sequence of drawing actions



The learner module The resolution module

Example: MakePerpendicular (AB, AD)

- Preconditions: Adjacent (AB, AD);
- Stroke: OrthoGesture(AB,AD).
- Postconditions: Perpendicular(AB,AD)



 \implies Solving the problem consists in solving the KG nodes by applying a sequence of these actions

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Resolution process example 1/3



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Resolution process example 2/3



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Resolution process example 3/3



Conclusion

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- Experiments realised in classrooms by Loustic colleagues
- We extracted 20 user data related to this exercise
- Goal: test the engine ability to correctly match the recognized stroke with the graph and to supervise pupil strategy



Proposed exercise

- C.M: the capacity of the engine of correctly matching the child's production with the knowledge graph;
- NB-solved: the number of solved nodes by the users;
- Correction: number of actions to solve the exercise given the child's plan.

Table 1	Ŀ	Results	on	users	data
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Block	C.M	NB-solved	Correction
Block 1	100% (2/2)	n = 12	None
Block 2	83.3% (5/6)	5 =< n =<8	4 actions (avg)
Block 3	100% (12/12)	n =<2	9 actions (avg)

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Synthesis

- Design supervision engine
- Tutor based on pattern recognition techniques
- Problem generation, automated resolution, supervision and feed-back

Future work

- Consolidate the tutor, include teacher constraints in instruction
- Analysis of the impact of of the engine on pupil performances

Thanks for your attention

