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How Quickly Can Wheel Spinning be Detected?

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Abstract

A wheel spinning detector for a cognitive tutor is developed. The detector reads a sequence of the correctness of applying particular skill performed by a student using the cognitive tutor. The response sequence is first fed to Bayesian knowledge tracing to compute a sequence of probability of mastery at each time a skill was applied by a student. The detector uses a single layer perceptron to make a binary classification for a response sequence into wheel-spinning and none-wheel spinning. The detector was validated using learning data taken from a Carnegie Learning Geometry Cognitive Tutor™ study. The results show that *the single layer perceptron detector can detect wheel spinning after observing 5 instances of skill application with high recall (0.79) but relatively low precision (0.25)*. The results suggest that our detector has a potential for scalable use such as *adaptive online course* where cognitive tutors are embedded into online courseware.

Wheel Spinning

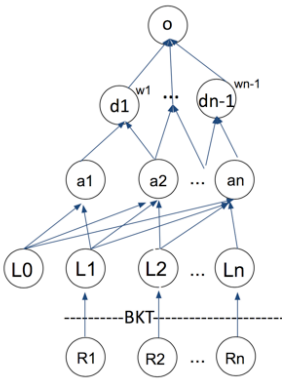
A situation that a student does not reach to a pre-defined mastery according to the knowledge tracing algorithm.

Although some students may eventually reach mastery after working on a considerably many number of problems, it is not practical to assume that students would be persistent under such situation. How many problems are too many is then an essential question in this context.

The goal of the current project is *to develop an algorithm to predict wheel-spinning as quickly as possible* while students practice on solving problems.

The Wheel Spinning Detector

A single layer perceptron with the input as a slope of a learning curve at each response on a particular skill. Weights for each neuron is computed to predict the wheel-spinning-ness of the given response sequence.



if (o < threshold)
then wheel spinning
else continue

*o = d1*w1 + ... + dn-1*wn-1*

for all *n* consecutive pairs, compute delta
di = a(i+1)-a(i)

for all *n* subsets, compute slope of linreg
ai = Linreg[L0 ... Li]

for all *n* responses, compute L value using BKT

n responses by the student

Evaluation Study

Data: Geometry Cognitive Model Discovery Closing-the-Loop from DataShop (PSLC). 2883 student-skill pairs with more than 5 responses.
After excluding mastery cases, there are 842 student-skill pairs that do not meet the mastery (Fig 1). Two human coders codifed them into wheel-spinning / none-wheel spinning (Fig 2).

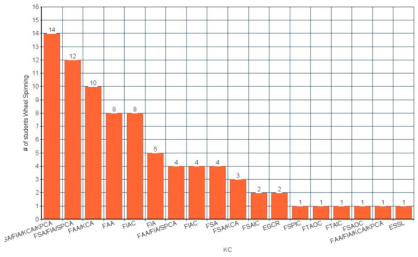
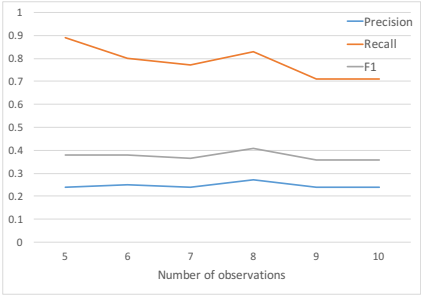


Fig. 1: Number of students wheel-spun on each skill

		Coder 2		
		W	C	Total
Coder 1	W	72	13	85
	C	5	752	757
	Total	77	765	842

Fig. 2: Inter-coder agreement of wheel-spinning coding

Our detector detects wheel-spinning with the high recall score only after observing 5 responses, but it makes high false alarm also.



Application: Adaptive Online Course

Cognitive Tutors (ITS) embedded into an online course with wheel-spinning detection can provide proactive scaffolding.