

# Foundations of Agent Programming

Prof. Michael Thielscher, Sebastian Voigt

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## Exercise 5.1

Prove that under the foundational axioms of the fluent calculus (Slide 4a/23) it follows for all  $m, n \geq 0$  that:

$$\text{a) } State(t) = State(s) + f_1 + \dots + f_n \supset$$

$$Holds(f, t) \equiv (Holds(f, s) \vee f = f_1 \vee \dots \vee f = f_n)$$

$$\text{b) } State(t) = State(s) - g_1 - \dots - g_n \supset$$

$$Holds(f, t) \equiv (Holds(f, s) \wedge f \neq g_1 \wedge \dots \wedge f \neq g_n)$$

$$\text{c) } State(t) = State(s) - g_1 - \dots - g_n + f_1 + \dots + f_n \supset$$

$$Holds(f, t) \equiv ([f = f_1 \vee \dots \vee f = f_n] \vee [Holds(f, s) \wedge f \neq g_1 \wedge \dots \wedge f \neq g_n])$$

## Exercise 5.2

Consider a one dimensional field of positions with exactly one object at each of them. The goal is to rearrange the objects in the field according to a given specification by only switching positions of objects that are directly next to each other. We use the following action and fluent:

$Switch(pos) \hat{=}$  the objects at position  $pos$  and position  $pos - 1$  are switched

$At(obj, pos) \hat{=}$  object  $obj$  currently is at position  $pos$

a) Using the fluent calculus, give a precondition axiom and a successor state axiom for this domain.

b) Write an Agent Logic Program (ALP)  $P$  by providing a predicate  $Strat/1$  which takes a list of objects  $[a_1, \dots, a_n]$  and generates an action sequence such that after execution the state  $At(a_1, 1) \circ \dots \circ At(a_n, n)$  is reached.

*Hint:* Repeatedly take the first element of the list which is not in its final position and switch it with the object one position below.

c) Give the expansion (cf. Slide 4a/7)  $exp(P)$  of the program  $P$  from b).

d) The following additional definition is necessary to provide the link between  $Poss/3$  from expanded ALPs to  $Poss/2$  from the fluent calculus axiomatization:

$$Poss(a, s, t) \stackrel{\text{def}}{=} Poss(a, State(s)) \wedge t = Do(a, s).$$

Formulate an initial state axiom such that  $A$  is at 2 and  $B$  is at 1 (and nothing else holds) and show that the expansion  $exp(P)$  from c) together with the fluent calculus axiomatization entails  $Strat([A, B], S_0, Do(Switch(2), S_0))$ .