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# Principles of AI Planning

## Exercise Sheet 2

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### Exercise 2.1 - Effect Normal Form

a) Transform the operator into ENF

$$\begin{aligned} & \langle \neg e \vee f, \\ & (a \triangleright (b \triangleright c)) \wedge \\ & (\neg d \triangleright c) \wedge \\ & (\neg(\neg c \wedge \neg a) \triangleright (d \wedge \neg e)) \wedge \\ & (d \triangleright \neg e) \rangle \end{aligned}$$

De Morgan's Law (8)

$$\begin{aligned} & \langle \neg e \vee f, \\ & (a \triangleright (b \triangleright c)) \wedge \\ & (\neg d \triangleright c) \wedge \\ & ((c \vee a) \triangleright (d \wedge \neg e)) \wedge \\ & (d \triangleright \neg e) \rangle \end{aligned} \quad \begin{aligned} & \langle \neg e \vee f, \\ & ((a \wedge b \vee \neg d) \triangleright c) \wedge \\ & ((c \vee a) \triangleright d) \wedge \\ & ((c \vee a) \triangleright \neg e) \wedge \\ & (d \triangleright \neg e) \rangle \end{aligned}$$

(7)

$$\begin{aligned} & \langle \neg e \vee f, \\ & ((a \wedge b) \triangleright c) \wedge \\ & (\neg d \triangleright c) \wedge \\ & ((c \vee a) \triangleright (d \wedge \neg e)) \wedge \\ & (d \triangleright \neg e) \rangle \end{aligned} \quad \begin{aligned} & \langle \neg e \vee f, \\ & ((a \wedge b \vee \neg d) \triangleright c) \wedge \\ & ((c \vee a) \triangleright d) \wedge \\ & ((c \vee a \vee d) \triangleright \neg e) \rangle \end{aligned}$$

(9)

$$\begin{aligned} & \langle \neg e \vee f, \\ & ((a \wedge b \vee \neg d) \triangleright c) \wedge \\ & ((c \vee a) \triangleright (d \wedge \neg e)) \wedge \\ & (d \triangleright \neg e) \rangle \end{aligned}$$

**b) Transform the operator into positive normal form**

$$\begin{aligned} & \langle \neg e \vee f, \\ & ((a \wedge b \vee \neg d) \triangleright c) \wedge \\ & ((c \vee a) \triangleright d) \wedge \\ & ((c \vee a \vee d) \triangleright \neg e) \rangle \end{aligned}$$

First we identify the negative atom  $\neg e$   
and we change it for  $\hat{e}$

We change effect  $d$  for  $d \wedge \neg \hat{d}$

$$\begin{aligned} & \langle \hat{e} \vee f, \\ & ((a \wedge b \vee \neg d) \triangleright c) \wedge \\ & ((c \vee a) \triangleright d) \wedge \\ & ((c \vee a \vee d) \triangleright \neg e) \rangle \end{aligned} \quad \begin{aligned} & \langle \hat{e} \vee f, \\ & ((a \wedge b \vee \hat{d}) \triangleright c) \wedge \\ & ((c \vee a) \triangleright (d \wedge \neg \hat{d})) \wedge \\ & ((c \vee a \vee d) \triangleright (\neg e \wedge \hat{e})) \rangle \end{aligned}$$

(8)

We change effect  $\neg e$  for  $\neg e \wedge \hat{e}$

$$\begin{aligned} & \langle \hat{e} \vee f, \\ & ((a \wedge b \vee \neg d) \triangleright c) \wedge \\ & ((c \vee a) \triangleright d) \wedge \\ & ((c \vee a \vee d) \triangleright (\neg e \wedge \hat{e})) \rangle \end{aligned} \quad \begin{aligned} & \langle \hat{e} \vee f, \\ & ((a \wedge b \vee \hat{d}) \triangleright c) \wedge \\ & ((c \vee a) \triangleright d) \wedge \\ & ((c \vee a) \triangleright \neg \hat{d}) \wedge \\ & ((c \vee a \vee d) \triangleright (\neg e \wedge \hat{e})) \rangle \end{aligned}$$

(8)

We identify the negative atom  $\neg d$  and  
we change it for  $\hat{d}$ .

$$\begin{aligned} & \langle \hat{e} \vee f, \\ & ((a \wedge b \vee \hat{d}) \triangleright c) \wedge \\ & ((c \vee a) \triangleright d) \wedge \\ & ((c \vee a \vee d) \triangleright (\neg e \wedge \hat{e})) \rangle \end{aligned} \quad \begin{aligned} & \langle \hat{e} \vee f, \\ & ((a \wedge b \vee \hat{d}) \triangleright c) \wedge \\ & ((c \vee a) \triangleright d) \wedge \\ & ((c \vee a) \triangleright \neg \hat{d}) \wedge \\ & ((c \vee a \vee d) \triangleright \neg e) \wedge \\ & ((c \vee a \vee d) \triangleright \hat{e}) \rangle \end{aligned}$$