数理解析研究所講究録
第 236 巻 1975 年 212-215

The Game of "Hana" - Representation and Analysis using a Typed Calculus

「花」ゲーム —— 型のある論理に基づく表現と解析

Shigeru Igarashi
(Research Institute for Mathematical Sciences, Kyoto U.)

五十嵐 滋（京都大学 数理解析研究所）

ABSTRACT: The game of "Hana" - a Japanese traditional card game, is treated. First, various data structures appearing in the representation of this game are axiomatized in a typed calculus which is a generalization of Scott's logic. The rule of the game itself is a rather complicated function (object formally) of a higher type representable in this calculus. An Algol-like language is introduced as the abbreviation of the terms of this particular type.

Two nontrivial theorems about this game will be proved.

山　柳　小野道風

```
Ax.12   HANA-AWASE  =  begin
        M := 1;
        index' := 0;
        while M≤12 do
begin   bouquet := Deal(X);
        flower := Ordering(bouquet(YAMA), X);
        index := Max{index', if <YANAGI, ONO'TOFU>ε bouquet(table)
                  or <KIRI, HOWO> ε bouquet(table)  then 2
                  else if  Eaεbouquet(table)[Point(a) = 20]
                       then 1 else 0};
        index' := if  <YANAGI, ONO'TOFU>ε bouquet(table)
                  &   <KIRI, ONO'TOFU>ε bouquet(table) then 2
                  else if <MATSU, TSURU> ε bouquet(table) &
                      <SAKURA, MANMAKU> ε bouquet(table)
                  or  <SAKURA, MANMAKU> ε bouquet(table)  &
                      <SUSUKI, MANGETSU>ε bouquet(table)
                  then 1 else 0;
        l := m := n := 1;
        while l≤5 & m≤5-3 & n≤3 do
begin if Active(Person(l), X)
     then beginplayer(n) := Person(l);
             n:=n+1
             Pay(Hand(Person(l)), table, Tax(m)× expo(2, index));
             m:=m+1 end;
        l:=l+1
end  ;
        while n≤3 do
begin   player(n) := Person(l);
        n:=n+1;
        l:=l+1
end  ;
        n:=1;
        while n≤3 do
begin   P:= player(n);
        if KARASU(bouquet(P)) or  6KASU(bouquet(P))
        then Show-down(bouquet(P)meet {a|Point(a)=1};
```

桐　鳳凰　幔幕

満月　桜

```
         Pay(Hand(player(n+1mod3)), Hand(P), TEYAKU-Bonus(bouquet(P)));
         Pay(Hand(player(n+2mod3)), Hand(P), TEYAKU-Bonus(bouquet(P)))
end else [];
         n:=n+1
end;
         t:=1;
         while bouquet(YAMA)≠∅ & not Battari(bouquet(Basket(player(
                                             t-1 mod 3)))) do
begin    P:=player(t mod 3);
         if bouquet(Hand(P))≠∅
     then begina:=Throw-in(P, X);
              Move(a, table);
              if (bouquet(table) join bouquet(Window(player(t+1 mod 3)
                  )) join bouquet(Window(player(t+2 mod 3))) meet
                  {b|Month(a)=Month(b)}  ≠ ∅
         then beginb:=Take-out(a, P, X);
                  Move(a, Basket (P));
                  Move(b, Basket(P))   end
         else [];
     end
  else [];
         c:=flower(t, X);
         Move(c, table);
         if bouquet(table) meet  {d|Month(c)=Month(d)} ≠ ∅
     then begind:=Take-out(c, P, X);
              Move(c, Basket(P));
              Move(d, Basket(P))   end
     else [];
         t:=t+1
end;
         if E  n ε{1,2,3} [Point(bouquet(Basket(player(n)))-
              {a |Flower-name(a)=YANAGIor  Flower-name(a)=KIRI} ≤ 20]
         then []
else beginn:=n+1;
         while  n≤3 do
     beginP:=player(n);
```

```
        C(n):=(DEKIYAKU-Bonus(bouquet(Basket(P)))+
              (if (n=1 or n=2)& Number(bouquet(Basket(P))) ≤ 8
                 or Number(bouquet(Basket(P))) ≤  10
               then 30 else 0)
              + Point(bouquet(Basket(P)))×expo (2, index);
        Pay(Hand(player(n+1 mod 3)), Hand(P), C(n));
        Pay(Hand(player(n+2 mod 3)), Hand(P), C(n));
        n:=n+1
  end;
        Pay(table, player( if max  {C(1), C(2), C(3)}  = C(1)
              then 1 else if  C(2)≤C(3) then  2 else   3,
              Cash(table))
  end;
        M:=M+1
end
end.
```

Theorems (informal description).

BIKI Theorem. The third active player can eventually take in a flower which is dealt to him and chosen by him arbitrarily.

88 Theorem. The total of the points of flowers taken in by the active players is always 88 times 3.

Lemma. Every flower is eventually taken in by some of the active players.

Corollary. The game of "Hana" terminates.

References.

[1] Shigeru Igarashi,

Admissibility of Fixed-point Induction in First-order Logic of Typed Theories,

Proceedings of the Symposium on Theoretical Programming, Computing Center, Novosibirsk, USSR Academy of Sciences, 1972 (Russian edition).

Stanford Artificial Intelligence Memo AIM 168 (English preprint).