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1. Given $\tilde{a}$ a geometric random variable with parameter α,
geometric distribution is : $P_{\tilde{a}}(a) = (1-\alpha)^{a-1}\alpha^1$

if we assume a_1 = $\tilde{a}$ equals a for $a = 1, 2, 3, \ldots$,
and a_2 = $\tilde{a}$ equals a for $a > 5$,

the probability should be $P_{\tilde{a}}(a_1) / P_{\tilde{a}}(a_2) = \frac{P_{\tilde{a}}(a_1 \cap a_2)}{P_{\tilde{a}}(a_2)}$

if) $a = 1,2,3,4,5$ then $P_{\tilde{a}}(a_1 \cap a_2) = 0$,

Since there will be no intersection of value a.

if) $a > 5$, then $P_{\tilde{a}}(a_1 \cap a_2) = P_{\tilde{a}}(a_1)$

Since every a_1 will be an intersection of a_2

$P_{\tilde{a}}(a_1) = (1-\alpha)^{(a_1-1)} \cdot \alpha^1$.

$$P_{\tilde{a}}(a_2) = P_{\tilde{a}}(a > 5) = 1 - (P_{\tilde{a}}(1) + P_{\tilde{a}}(2) + P_{\tilde{a}}(3) + P_{\tilde{a}}(4) + P_{\tilde{a}}(5))$$
$$= 1 - (\alpha + (1-\alpha)\cdot\alpha + (1-\alpha)^2\alpha + (1-\alpha)^3\alpha + (1-\alpha)^4\alpha)$$
$$= (1-\alpha - (1-\alpha)\alpha - (1-\alpha)^2\alpha - (1-\alpha)^3\alpha - (1-\alpha)^4\alpha)$$
$$= (1-\alpha)(1-\alpha-(1-\alpha)\alpha - (1-\alpha)^2\alpha - (1-\alpha)^3\alpha)$$
$$= (1-\alpha)^2(1-\alpha-(1-\alpha)\alpha-(1-\alpha)^2\alpha)$$
$$= (1-\alpha)^3(1-\alpha-(1-\alpha)\alpha)$$
$$= (1-\alpha)^4(1-\alpha)$$
$$= (1-\alpha)^5$$

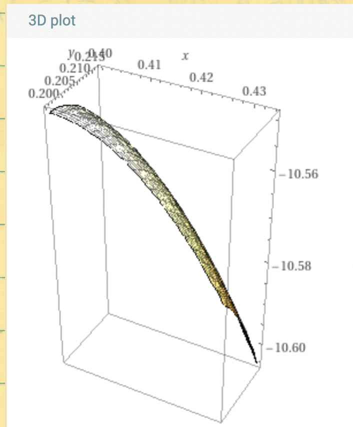
$\therefore$ if $a \le 5$, $P_{\tilde{a}}(a_1)/P_{\tilde{a}}(a_2) = \frac{P_{\tilde{a}}(a_1 \cap a_2)}{P_{\tilde{a}}(a_2)} = 0$

$a > 5$, $P_{\tilde{a}}(a_1)/P_{\tilde{a}}(a_2) = \frac{P_{\tilde{a}}(a_1 \cap a_2)}{P_{\tilde{a}}(a_2)} = \frac{P_{\tilde{a}}(a_1)}{P_{\tilde{a}}(a_2)} = \frac{(1-\alpha)^{(a_1-1)}\cdot\alpha^1}{(1-\alpha)^5} = \boxed{(1-\alpha)^{(a_1-6)}\cdot\alpha^1}$

2. (a) $P(\theta, a) = \frac{10!}{4!4!2!} \theta^4 a^2 (1-\theta-\alpha)^4$

$$\log P(\theta, a) = \log \frac{10!}{4!4!2!} + 4\log(\theta) + 2\log(a) + 4\log(1-\theta-a)$$

<Plot>



(b) By taking the derivative of both θ and a, we can calulate θ, a.

~~Let~~ 1) $$\frac{d}{d\theta} \log P(\theta, a) = 0 + \frac{4}{\theta} + 0 + \frac{4\times(-1)}{(1-\theta-a)} = 0$$

$$\Rightarrow \frac{4}{\theta} = \frac{4}{(1-\theta-a)}, \quad \theta = (1-\theta-a) \quad \therefore \theta = \frac{1-a}{2}$$

2) $$\frac{d}{da} \log P(\theta, a) = 0 + 0 + \frac{2}{a} + \frac{4(-1)}{(1-\theta-a)} = 0, \quad 2a = 1-\theta-a \quad \therefore \theta = 1-3a$$

Since $\theta = \frac{1-a}{2} = 1-3a$, $1-a = 2-6a$, $5a = 1$, $\boxed{a = \frac{1}{5}}$, $\boxed{\theta = \frac{1-\frac{1}{5}}{2} = \frac{2}{5}}$

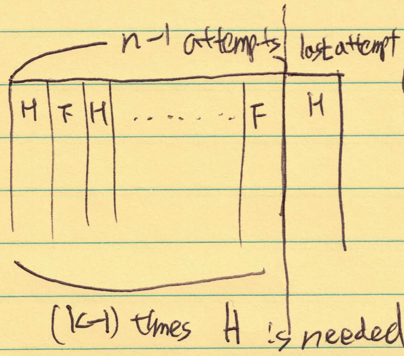
(c) $P(\text{Gary wins}) = \frac{4}{10} = 2/5$

$P(\text{Anish wins}) = \frac{2}{10} = 1/5$

$P(\text{draw}) = \frac{4}{10} = 2/5.$

from 10 chess games. This result is same as (b), which makes this nonparametric model same as parametric model

3. If a player needs total n attempts and hits a certain number k times, last attempt should be hitting a certain number.



(H : Hits a certain number)
F : fails to hit a certain number)

So, for $(n-1)$ attempts, we have $(k-1)$ Hits and $(n-1)-(k-1)$ none hits in binominal distribution.

Assuming the probability of success in each attempt as θ, and number of required attempts k, pmf should be as below

pmf) $\underline{{}_{n-1}C_{k-1} \cdot (\theta)^{k-1} \cdot (1-\theta)^{(n-1)-(k-1)}} \cdot \theta$

$p(\text{last attempt} = \theta)$

$$\boxed{= {}_{n-1}C_{k-1} (\theta)^{k} \cdot (1-\theta)^{n-k}}$$