PEROIDICITY DETECTION OF

A SIGNAL

By

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INTRODUCTION:

Periodic signals are those signals which repeat after a certain time periods.Examples:Sine wave ,Cos wave etc.

Aperiodic signals or noise are those signals which have no definite time periods after which it will repeat itself.

Example:Speech,Random signals etc.

Basically in this project we are going to detect periodicity of a signal which has both periodic and aperiodic elements.

Periodicty is the time period after which the signal repeats itself.

For this we have two methods :

1.)Using frequency spectrum to analyse the periodicity

of the signal.

2.)Using Ramanujan's Filter Bank to analyse the periodicity of the signal.

Software which is used in this process is Matlab.

Our main motive is to deduce which is faster and efficient method

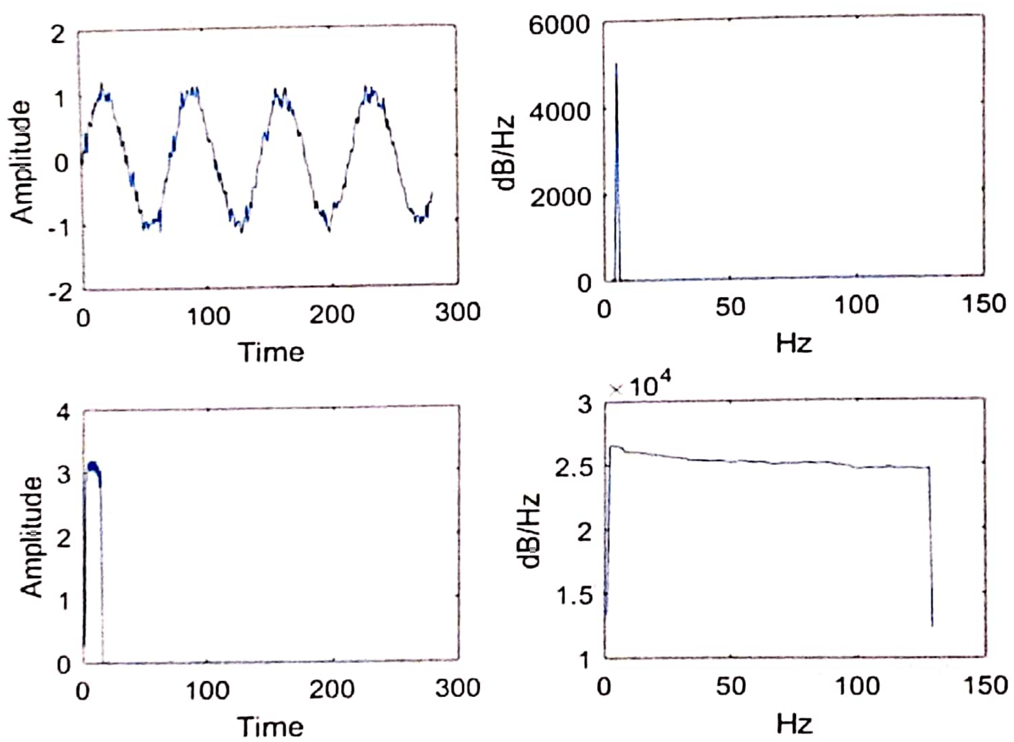
PROCEDURE:

1.)Using Spectral Analysis: In this process we have two signals :

I.)Sinusoidal signal:Here we have a simple combination of a sine wave and noise.So firstly we have done power spectral analysis on this signal.Further we have performed multi tapering on the signal to conduct multifrequency searches on the signal for multiple periodicity.

The Matlab code for the above process is attached below


gp.txt (Appendix-1)



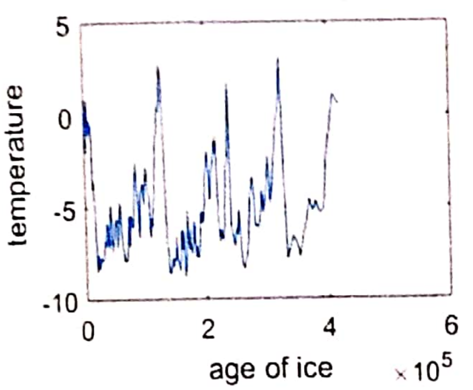
The peak in the power spectral density indicates periodicity.As per the Matlab code attached above period

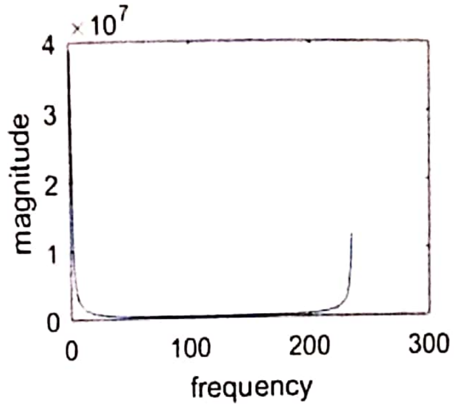
was calculated to be 73.

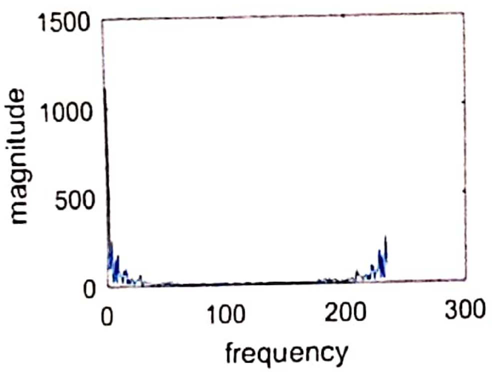
II.)Random Signal:Here we have taken a random signal

which is a data plot of temperature of ice over a certain period of time using deuterium.It was plotted using data sheets.The fourier transforms of the temperature of ice

and period of time were obtained separately.Both of them were plotted.



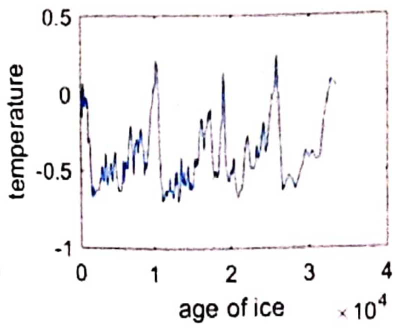


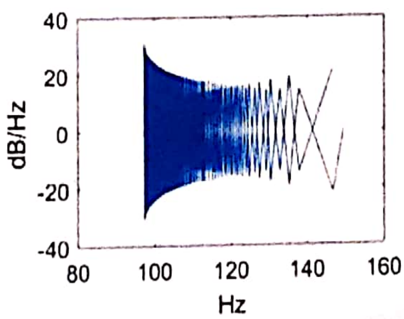


Both the parts of the signal (i.e,Temperature Change and

Age of Ice) were passed through an averaging filter.

The signal was re-plotted and its power spectral density was observed .





The period was deduced to be 82.14 years from the spectral analysis.The Matlab code for the following program is encoded:

random signal.txt (Appendix-2)

2.)Using Ramanujan's Filter Bank: Ramanujan's Filter Bank works on the principal of Ramanujan's sum.

According to Ramanujan's sum we know that

The qth Ramanujan sum ($q \geq 1$) is a sequence in n defined as

$$c_q(n) = \sum_{\substack{k=1 \\ (k,q)=1}}^{q} e^{j2\pi kn/q} = \sum_{\substack{k=1 \\ (k,q)=1}}^{q} W_q^{-kn} \qquad (3)$$

Thus the summation runs over only those values of k that are coprime to q. So, the sum (3) has precisely $\phi(q)$ terms, and

$$c_q(0) = \phi(q) \qquad (4)$$

From (3) we see that $c_q(n)$ is periodic:

$$c_q(n+q) = c_q(n) \qquad (5)$$

Equation (3) also shows that the DFT of $c_q(n)$ is

$$C_q[k] = \begin{cases} q & \text{if } (k,q) = 1 \\ 0 & \text{otherwise.} \end{cases} \qquad (6)$$

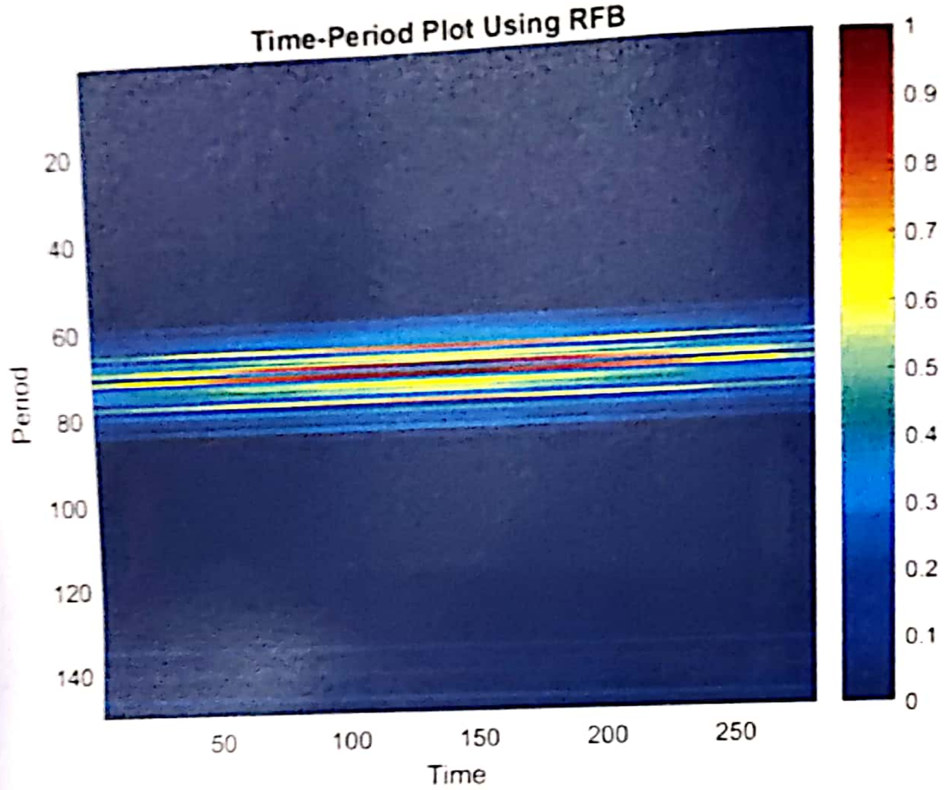
As we see Ramanujan's sum operates on a signal in the range of (k.q).The sequences are detected only when k and q are co-prime i.e, l.c.m(k,q)=1.For obtaining the period of the signal we have to take the l.c.m of the detected sequences.If we have the periodic sequences as (N1,N2,N3,………Ni).

The time period is obtained as Period=L.C.M(N1,N2,N3,………Ni).

A.)For sinusoidal signal: We applied the Ramanujan Filter Bank for the sinusoidal signal which we have used for the spectral analysis.The Matlab code for the program is encoded :

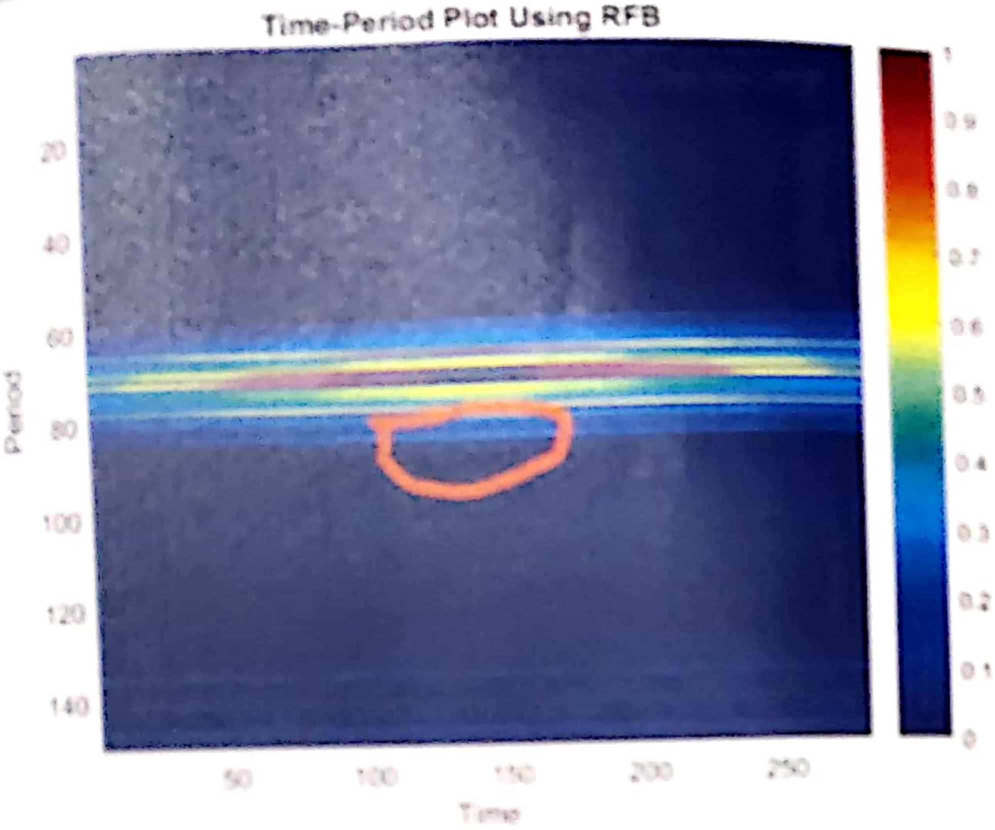
(Appendix-3)

We get the following period v/s time analysis:



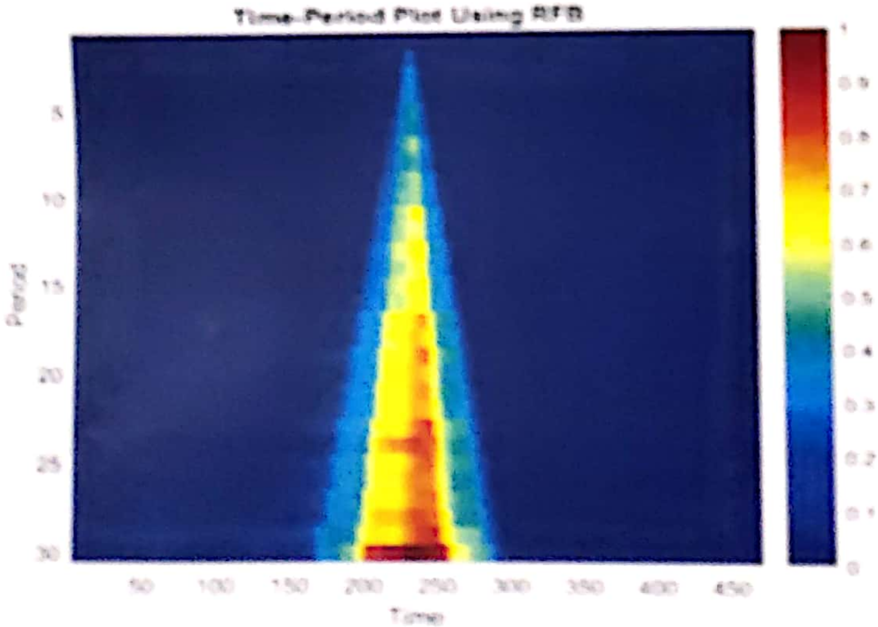
We have obtained several periodic sequences .But the time period is determined by the l.c.m of all of them.

So here we have the smallest period which ranges from about 110 to 180.So that gives the time period of about 70(approx).

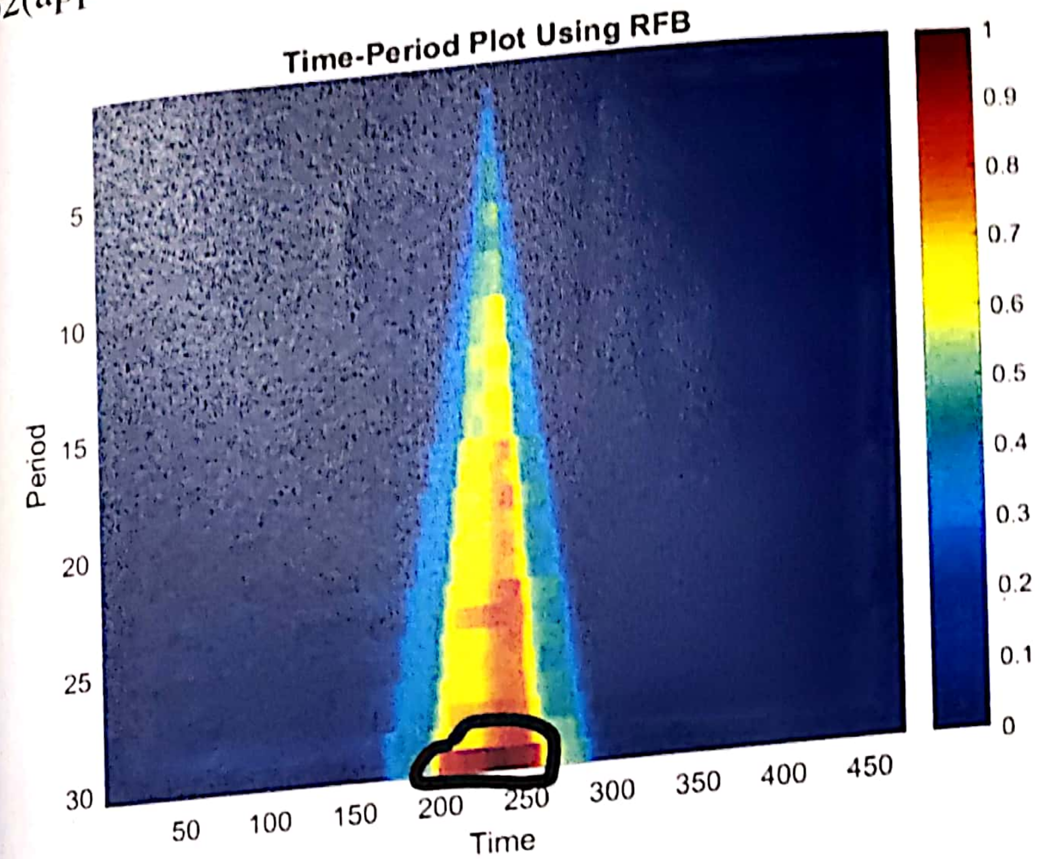


So the main disadvantage is that nested periods are difficult to detect.

B.)For Random Signal: We have used the same signal that we have used for spectral analysis.Application of Ramanujan's Filter Bank yields the following time v/s period plot:



The period ranges from 198 to 260.So we get the time period as 62(approx).



The Matlab code for the program is encoded as the following:

(Appendix-4)

CONCLUSION:

It is hereby concluded that Ramanujan's Filter Bank is an efficient method for detecting periodic sequences in a signal.But it has its own drawbacks.One of the major draw back that have been concluded is that nested periodicities are hard to detect due to the colour contrast as in the case of using Matlab.

APPENDIX:

1.)

```
clc;
close all;
clear all;
F=0.014;
T=1/F;
L = 280;
t = (0:L-1);
subplot(2,2,1);
n=sin(t);
k=randn(size(t));
x = sin(2*pi*F*t)+0.1*randn(size(t));
plot(x);
ylabel('Amplitude');
xlabel('Time');
subplot(2,2,2);
xdft = fft(x);
Pxx = 1/(L*F)*abs(xdft(1:length(x)/2+1)).^2;

plot(Pxx);
xlabel('Hz'); ylabel('dB/Hz');
s=0;
for t=0.0:1.0:4000.0
    s=n+s;

end
m=s/4000;
disp(m);
v=0;
for t=0.0:1.0:4000.0
    l=n-m;
    v=l+v;

end
var=v/4000;
disp(var);
s1=0;
for t=0.0:1.0:4000.0


    s1=k+s1;
end
m1=s1/4000;
disp(m1);
v1=0;
for t=0.0:1.0:4000.0
    l1=k-m1;
    v1=v1+l1;
end
var1=v1/4000;
disp(var1);
snrrat=10*log10(var/var1);
disp(snrrat);
subplot(2,2,3);
mtp=pmtm(x);
plot(mtp);
ylabel('Amplitude');
xlabel('Time');
u=snr(mtp);
subplot(2,2,4);
mtp1=pmtm(Pxx);
plot(mtp1);
xlabel('Hz'); ylabel('dB/Hz');
t=findpeaks(x);
Period=mean(diff(t))
```

2.)

```
subplot(2,2,1);
x=Ageofice;
y=Temperaturevariation;
t=plot(Ageofice,Temperaturevariation);
ylabel('temperature');
xlabel('age of ice');
subplot(2,2,2);
k=x(4:238);
l=y(4:238);
o=fftn(k);
r=fftn(l);
m=plot(abs(o));
xlabel('frequency');ylabel('magnitude');
subplot(2,2,3);
i=plot(abs(r));
xlabel('frequency');ylabel('magnitude');
p=reshape(k,1,[]);
esp=(k(235)-k(1))/length(k);
d=xcorr(p,p);
v=abs(findpeaks(d));
period=mean(diff(v)*esp);
subplot(2,2,4);
b=0.08;
a=1;
t=filter(b,a,k);
b=filter(b,a,l);
plot(t,b);
ylabel('temperature');
xlabel('age of ice');
l=cat(1,t,b);
v1=abs(findpeaks(l));
freqperiod1=abs(mean(diff(v1)*esp));
period1=(1/freqperiod1);
plot(10*log(fft(l)));
xlabel('Hz');ylabel('dB/Hz')
```

3.)

```
clc;
close all;
clear all;
F=0.014;
T=1/F;
L = 280;
t = (0:L-1);
subplot(2,2,1);
n=sin(2*pi*F*t);
k=randn(size(t));
x = sin(2*pi*F*t)+0.1*randn(size(t));
plot(x);
ylabel('Amplitude');
xlabel('Time');
subplot(2,2,2);
xdft = fft(x);
Pxx = 1/(L*F)*abs(xdft(1:length(x)/2+1)).^2;
plot(Pxx);
xlabel('Hz'); ylabel('dB/Hz');
[maxval,idx] = max(abs(xdft));
freq = (F*(idx-1))/length(x);
time=1/freq;
s=0;
for t=0.0:1.0:4000.0
     s=n+s;
end
m=s/4000;
disp(m);
v=0;
for t=0.0:1.0:4000.0
     l=n-m;
     v=l+v;
end
var=v/4000;
disp(var);


s1=0;
for t=0.0:1.0:4000.0
     s1=k+s1;
end
m1=s1/4000;
disp(m1);
v1=0;
for t=0.0:1.0:4000.0
     l1=k-m1;
     v1=v1+l1;
end
var1=v1/4000;
disp(var1);
snrrat=10*log10(var/var1);
disp(snrrat);
subplot(2,2,3);
mtp=pmtm(x);
plot(mtp);
ylabel('Amplitude');
xlabel('Time');
u=snr(mtp);
subplot(2,2,4);
mtp1=pmtm(Pxx);
plot(mtp1);
xlabel('Hz'); ylabel('dB/Hz');
t=findpeaks(x);
freqp=mean(diff(t));
time=(1/freqp);
RFB(x,150,5,4,0.1)
```

4.)

```
subplot(2,2,1);
x=Ageofice;
y=Temperaturevariation;
t=plot(Ageofice,Temperaturevariation);
ylabel('temperature');
xlabel('age of ice');
subplot(2,2,2);
k=x(4:238);
l=y(4:238);
o=fftn(k);
r=fftn(l);
m=plot(abs(o));
xlabel('frequency');ylabel('magnitude');
subplot(2,2,3);
i=plot(abs(r));
xlabel('frequency');ylabel('magnitude');
p=reshape(k,1,[]);
esp=(k(235)-k(1))/length(k);
d=xcorr(p,p);
v=abs(findpeaks(d));
period=mean(diff(v)*esp);
subplot(2,2,4);
b=0.08;
a=1;
t=filter(b,a,k);
b=filter(b,a,l);
plot(t,b);
ylabel('temperature');
xlabel('age of ice');
l=cat(1,t,b);
v1=abs(findpeaks(l));
freqperiod1=abs(mean(diff(v1)*esp));
period1=(1/freqperiod1);
plot(10*log(fft(l)));
xlabel('Hz');ylabel('dB/Hz');

RFB(1,30,3,2,0.01)
```

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INTERNSHIP CERTIFICATE

Mr. Agnibha Chatterjee, a second year student of the School of Electronics, Kalinga Institute of Industrial Technology, Bhubaneshwar, Odisha has worked on ``Periodicity detection in a signal'' under my supervision during 6 May -- 20 June, 2019. During this time, he has carried out study of existing techniques and also worked on MATLAB implementations of these.

Agnibha has been very sincere and hardworking during his entire period here. I wish him success in all his efforts.

Sarbani Palit
20.6.'19
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