Generating song lyrics using recurrent neural networks

Project for the course Neural Networks at Faculty of Electrical Engineering and Computing, University of Zagreb

Ena Car Ena.Car@fer.hr Pavao Dužević Pavao Duzevic@fer.hr Damjan Grubelić Damjan.Grubelic@fer.hr

Josipa Kaselj Josipa.Kaselj@fer.hr Magdalena Šimunec Magdalena.Simunec@fer.hr

Eva Šmuc Eva.Smuc@fer.hr

Abstract—This document is a project report for the Neural Networks course at Faculty of Electrical Engineering and Computing in Zagreb. It describes an implementation of a recursive neural network which is used for generating song lyrics based on given set of song lyrics.

Index Terms—RNN, neural networks, generating song lyrics

I. INTRODUCTION

Writing meaningful lyrics has always been a challenge even to the best of songwriters. Since more and more jobs are being automated, especially now with the rise of popularity of various machine learning methods, there is also an initiative aimed at computers writing songs. The goal is to feed a model with lyrics of existing songs and then to use it for generating new lyrics. Those generated song lyrics aren't supposed to be word-for-word equal to those used for training the model. Still, it wouldn't be sensible having it generate random words, either. The goal is having the model memorize the lyrics of the songs it is trained on (motifs) and then combine them *sensibly*, i.e. having the model memorize "relationships" between the words through their relative order. In this project, it is being done using recursive neural networks (RNN), which are able to take in account previous outputs when generating new one, thus adding temporality. The models have been trained on several subsets of the "150K Lyrics Labeled with Spotify Valence" dataset from kaggle.com.

II. EXISTING SOLUTIONS AND BRIEF LITERATURE OVERVIEW

A. Automatic Rap Lyrics Generation

Variation of RNN called LSTM architecture creates a better language model than a regular RNN. [1] According to Potash, Romanov and Rumshisky, Long Short-Term Memory (LSTM) language model produces better lyrics than a baseline model. They attempted to piece together lyrics for a specific artist, but their model was limited in generating lyrics for a genre. As a result of training their model with sets of lyrics, they noticed corresponding rhyming words.

Another example of A Rap Lyrics Generator was developed by Nguyen and Sa [2]. They used database of approximately 40000 existing rap lyrics. After failure to get profound results when using linear-interpolated trigram model approach, they shifted to a quadgram model. Also, they succeeded to generate sentences that rhyme with each other. At the end, generator worked decently, but the content of the lyrics did not relate to a specific theme.

B. Automatic Generation of Poems

Wishful Automatic Spanish Poet was the first generating program for poems which used artificial intelligence and natural language generation techniques together. The whole system of WASP is based on a forward reasoning ruled-based system. Users were asked for inputs which were then used as seeds and results recieved were not very efficient in generating lyrics [3].

C. Rhyme Detection

Hirjee and Brown have developed a probabilistic model and in addition to it they have built up a rhyme detection tool based on that model [4] [5]. Tool analyzes phoneme patterns in words and model is trained on a set of lyrics that were manually annotated for rhyming words.

D. Classification of Lyrics

Mayer, Neumayer and Rauber used rhyme and style features to classify and process lyrics [6]. They followed the fact that a rhyme is two words that when spelt sound similar and generally used it for words at the end of verses.

E. Natural Language Processing and Lyrics Generation

With basic natural language processing tools, song lyrics can be analysed by using a Naive Bayes classifier. Mahedero, Cano and Martinez used that to identify languages. Also, they used it for classification based on themes and to search for similarities between them. The languages which were used for the experiment: English, Spanish, German, French and Italian. Given results were approximately 94% accurate. The conclusion they came to is that the identification of languages was easier task compared to the others.

III. SOLUTION IMPLEMENTED BY THE PROJECT TEAM

Since generating the lyrics requires memorizing word ordering so that lyrics make sense, RNNs have been used, as that class of neural networks is better for memorizing sequences. Sequences used as RNN inputs can be words as well as characters. In this project, the word-based model has been used, so that all generated lyrics use existing words and the RNN doesn't have to memorize character ordering inside the words on top of word order.

A. Choosing the right dataset

The lyrics needed for training such model can be scraped using the webscrapers on lyrics websites, downloaded using a Python API like *lyricsgenius* or downloaded as a readily available dataset. With the latter being the simplest method of the three, yet equally suitable, the project team opted for the "150K Lyrics Labeled with Spotify Valence" dataset because of its exhaustiveness which provides a simple way to extract almost any arists' lyrics and offers diversity of songs and genres. Since it is too big to be processed on the project team's machines, only the first 200 lyrics with more than 60% English words in them have been used for training the most of the models.

B. Preprocessing the dataset

Since the lyrics texts often contain additional info that is not part of actual song lyrics (like the chorus tag or the name of the artist performing the next verses) and since such tags are most commonly enclosed in square brackets, everything inside square brackets has been removed from the lyrics to reduce cluttering with info that may not be correct in generated lyrics and would interfere with memorizing relationships of words and motiffs.

However, another kind of interference was made in order to memorize line endings. The "word" *endl* has been added to the end of each line in order to help with rhyming and breaking lines of generated songs in meaningful places.

After adding the *endl*, each word from the dataset has been stripped of punctuation and converted to lowercase. Each word has been mapped to a unique number that would be used as network input.

Those numbers (tokenized words) have been grouped into sequences of \mathbf{up} to n lines, i.e. verses. The sequences have been padded to the length of the longest sequence with zeros. The last number in each sequence would later be expected output for the input which is the rest of the sequence.

C. Building the models

Three different architectures of neural network have been used in order to determine which one would provide the best results. Basic network architecture consists of an input layer, one or multiple hidden layers and an output layer.

First architecture consists of one hidden SimpleRNN layer, which is a fully-connected RNN where the output is to be fed back to input.

Second architecture has an LSTM as a hidden layer and a Dropout layer in order to prevent overfitting.

The third and most complex architecture consists of one Bidirectional LSTM layer, a Dropout layer in order to prevent overfitting, LSTM layer and two densely-connected NN layers.

The softmax function is used as the activation function in the output layer of all the neural network models since they predict a multinomial probability distribution. Adam optimizer was used since it achieves good results faster than classical stochastic gradient descent optimizer.

D. Training the models

Each model was trained for a period of 20, 50, 80 and 110 epochs in order to determine when underfitting and overfitting happens.

E. Generating the lyrics

The lyrics are being generated line by line, with tokenized words from n previous lines as the input for the model. The first line doesn't have previous lines, but a seed text may be added instead. Model then predicts for each unique word from the corpus how likely it is to appear next. That word is added to the song and then the model makes a new prediction for the next word with the last one added to the input.

Since lyrics tend to be repetitive, especially after overfitting, the model may fall in loop predicting the same lyrics over and over. That's why the genrating function explicitly prevents two lines starting with the same word by picking the second word that is the most likely to appear. It also reduces the impact of overfitting by memorizing the exact lyrics from dataset:

Any song with identical words at the start of two close lines cannot be exactly reproduced by the generator.

Number of lines is randomly selected from the same distribution as the numbers of lines of the lyrics in the dataset.

F. Evaluation of the generated lyrics

The measure of the model fitness during the training has been "how well the model reproduces the lyrics it was given". However, the goal isn't to reproduce the same lyrics that already exist, but to generate *new* meaningful songs.

Measuring how good some lyrics are is a problem of its own, because it's highly subjective and hardly quantifiable. There are ways to analyze the structure of generated lyrics and the distribution of the words [7], but with such a diverse dataset, there isn't a proper point of reference and that still isn't sufficient to tell if the lyrics really are good.

So for the evaluation, apart from how the lyrics looked to the project team, an online tool "made by songwriters" was used as they may have more proficiency in analysis — The Lyric Assessor.

The Lyric Assessor is calibrated using the lyrics of 295 songs that are cited by songwriters as being examples of well-crafted songs. It scores the lyrics with a number ranging form -5 to 5. Scores above zero (maximum = 5) indicate that the lyrics are linguistically more like lyrics often mentioned as archetypically well-crafted songs by songwriters. Scores below

zero (minimum = -5) indicate that the lyrics are linguistically less like lyrics often mentioned as archetypically well-crafted songs by songwriters. The Lyric Assessor has an accuracy of approximately 80%. It uses computational linguistics to compare lyrics with a corpus of songs regarded as "well-crafted" by songwriters and with a corpus of songs not so regarded by songwriters.

IV. PROJECT RESULTS

The generated lyrics can be found in the Appendix VII. Scores by the Lyric Assessor for the generated lyrics are given in Table I, which is plotted in "Fig. 2".

TABLE I
THE LYRIC ASSESSOR SCORES DEPENDING ON MODEL ARCHITECTURE
AND TRAINING TIME

| Number of | Architecture | | |
|-----------|--------------|------------|--------|
| epochs | SimpleRNN | SimpleLSTM | BiLSTM |
| 20 | -0.9 | 1.9 | -4.3 |
| 50 | 1.7 | 2.1 | 1.6 |
| 80 | -0.3 | 2.6 | 3.1 |
| 110 | 1.3 | 0.5 | 0.8 |

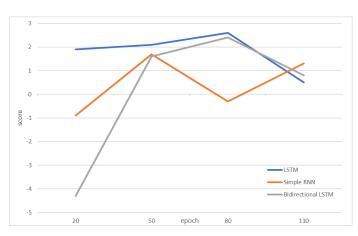


Fig. 1. Score graph

A. Comparison by architecture

Comparison of the lyrics generated after 80 epochs by three different models: VII-C, VII-G, VII-K. When comparing the results, we look at how well the song is crafted in terms of syntax and semantics, and the similarity to what is generally perceived as 'well written' lyrics. Simple RNN architecture generated lyrics where the verses lack syntactic sense and words following one another seem very random (VII-G). The most complex architecture based on Bidirectional LSTM generated lyrics which demonstrated overfitting. After training the model for 80 epochs, it generated song lyrics asssembled from verses identical to existing songs from the dataset. Architecture with one hidden LSTM layer and regularisation provided satisfactory results(VII-C). The generated lyrics improved in terms of syntax and semantics when compared to the ones generated by Simple RNN model. The words do not seem

as random, while overfitting is avoided due to a balance of simpler architecture and right amount of epochs used for training the model.

B. Comparison by epoch

It can be concluded from the scoring, that for Simple LSTM results keep getting better up until 80 epochs. Training this particular model for more than 80 epochs decreases the score. The more complex model based on Bidirectional LSTM seems to achieve the best score - 3.1 for 80 epochs. This makes sense since the song lyrics generated for this model after 80 epochs are almost identical to verses provided in the dataset, so The Lyric Assessor is more likely to consider this song archetypically well-crafted.

Comparison of the LSTM and RNN architectures during training can be seen in "Fig. 2" (accuracy) and "Fig. 3" (categorical crosentropy loss). Despite being more accurate, SimpleRNN's generated lyrics aren't noticably better than SimpleLSTM, while the BiLSTM, being more complex produces the best results as expected.

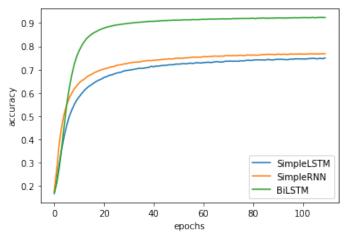


Fig. 2. Accuracy of the models

C. Comparison by artist

To better show how generated lyrics reflect the dataset a model is trained on, a simple LSTM model was trained for 110 epochs on a dataset consisting of only Boney M.VII-M songs, and it was repeated on Iron Maiden's songs VII-N.

Both generated lyrics contain recognizable words from the artists' songs. Their style was harder to replicate. Some of the words even form whole lines identical to those in the songs, which is a sign of overfitting.

V. COMPARISON WITH EXISTING SOLUTIONS

For comparison, we have used an already existing project with a character-based approach with mild modifications.

The important difference from our solution is that this network must learn words and the order of the letters to get a meaningful word. Also, has to learn the order between the words.

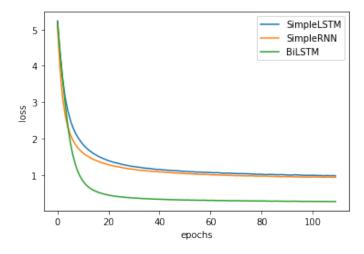


Fig. 3. Categorical crossentropy of the models

The project uses the Sequential model which is one way of creating deep learning models. It is convenient to use when each layer has only one input tensor and one output tensor. The Sequential model is defined by passing a list of layers to the Sequential constructor.

Firstly, words are presented as vectors that need to be evaluated to match something meaningful and that is done by calling embedding. Embedding turns positive integers into dense vectors of fixed size.

After that, Gated Recurrent Units (GRU) is used to remember a certain number of previous words in a clever way (rnn_units). GRU is used as a closing mechanism in RNN (something like LSTM, but with fewer parameters).

Finally, a dense layer is a deeply connected layer from its preceding layer which works for changing the dimension of the output by performing matrix-vector multiplication and gives information about the most probable word that is expected.

We used similar parameters and architectures as with our model for comparison. The most noticeable disadvantage is that some words do not make sense, that is, we can call them "garbage".

An important parameter when generating lyrics is **temperature**. Low temperature will produce predictable results, but with higher temperature lyrics will become more creative. That can be seen in VII-P, which is a more complex model than VII-O, but contains less words from the songs and less correctly spelled words in general, but better recovers from the overfitting loop.

VI. CONCLUSION

Generally, the most complex architecture: the LSTM with hidden layers overfits most quickly and training it on a bigger dataset may produce good results in the same number of epochs. Simple LSTM is faster. It produces better results than simple RNN model.

Generally, the resulting lyrics generator doesn't produce completely random lyrics nor does it really create lyrics that make sense. Given the limited resources and time, the results are as expected because the results from the literature aren't much better.

Further work based on this project might include developing a metric that would measure lyrics fitness. That may also enable using reinforcement learning which could lead to better results.

Another approach that may yield better results would be using GPT instead of RNN.

VII. APPENDIX

A. Simple LSTM - 20th epoch

i'm running for my life and won't you believe it how can you need it

i will never rest the system's sympathy california california california it's merilee since you been gone

i know you want to run far away from one more but i don't know what you want to get tooken and you think of you were not there's a fire in the belt of hercules don't let up what you want me any slack who cares about you i thought i did man i need you i need you

you know you know what you told me
no is the house we used to live in
this is a place and you gotta real too
and the way i feel me
i gotta ask to you you
but i do you i need you like the questions ones though

t i p man you don't need to get to you you know my song no fist is needed when you call

just because of you boy
oh boy
i know you should hate me
but you rearrange me
coming in my ear
baby
i've got a hand for you
'cause i wanna run with you
won't you let me run with you

have fun again i want you to have fun just like little children like the little children know how they have fun

B. Simple LSTM - 50th epoch

i'm going and i can't say you i know that i have to do 'till i want to be 'cause i got it so much it's not right to you

i know you want to run far away from one more but now these days are gone i'm not so self assured now i find i've changed my mind get to be

there's a chink of light there's a burning wick what you say your arms and you can't feel f*** it like our first time i get off the mess just like you feel a lot and zip up an dog the sun is sinking low when i was raised different what you feel baby

have fun again i want you to have fun just like little children like the little children know how they have fun

i need you but you don't know what is not for you my love to escape i'm why not when i want to be in a man so pleasant and heavenly when you and you can give me i'm tell you

we keep 'em hotter than the fire are good i cried in the sack with the flower you can't put the same old time and i don't have to pretend since you're gone

C. Simple LSTM - 80th epoch

it's a man in a glass house tonight and i only want to treat you right i love i love you true

love is all that's left in the end my house and i'll take it so i have got a lot of what you got to keep us from the and let the time i come to a man when i'm out and in a speed of your eyes and the way i would not believe it like these faces talk of shit by y'all happened shining with a crime and the hood ask about about a body so stand out here in his band on your eyes what's on my ass so hard and all i don't quit like a phoenix

never never love love love all the time don't mind you got me i need it

t i p y'all wrong with you a way and forget i know i need a man i can act but i got a kid and i can always done

when i can see the switch man out in the freight yard waving his lights at my train red fir stopping my heart from beating green in the air

you gave me my man and his little thing to make me like make me were it but i have like a lot of love in store once in the lot of the sky the sky is the mountains while the system tell me by cause i see the star is in

D. Simple LSTM - 110th epoch

it's a man in the glass house than the days is for a lie

look at the only the shape don't go and i don't get to the places that i want to go to find some back my time don't think i can't stop

and you seek with you i can't think you standing by the yes they're gonna show you see my think i stay in the night say the f*** we used to live in where the girls you know i love things just like little children

like the little children know how they have fun meanwhile back at the ranch i think you are my condition

and you seek i love you

like you walk for the life you see the first man when i get out and i get my shit i miss her lips and i feel the unity you can't believe the hook no shit tonight oh oh oh oh

i want you to have fun have fun again you asked me to prove my skills then i showed ya the clock ticks down seems i wait the same old places

i was a brand new world and they've loves me just like you and not get to get up with me and you say that i will live my soul so never never love

never never love love
all the time
don't mind
i can't think you if you can take me
you don't know whatcha got till it gone
but you don't know what you want and this ain't how it
should be
why you gotta be so cold
pleasing you seems impossible
girl you know you're black to the bone

E. Simple RNN - 20th epoch when you've hearts

and i'm all over my tears but i walk away i wish i could bring it back wish i could take it back

keep it in the family

now i was wrong and i'm so that he got that i love you i got that i got that i got that what i only like let you want to you so i hope that take everything don't think that i've got to only so empty here

the real world's outside your door
you can't take it in you
it's here for long
and you can't be happy
oh why still
he said if i could even that i was th' way that comes out this
rest

now i can see you don't belong if i open all the day to make that mind and i'll take the taste to be it's far the man was treating me the feeling but at the mountain

they looked people the water is the voices wake his toy and heaven has its ways love will do on a doubt to work through the blaze doubling up the stacks he said if god lives by the gun

F. Simple RNN - 50th epoch

so i said
i don't had a calculator
to know i'm gonna see you later
and i don't need a secretary
for the next door all make it a rose to my mind
you get new more of sleep
a futile attempt to uphold your claim
as i don't even myself but i want to do so many not believe
some sleep

this fire's down they put mind by the good move your heart i was the day when i know what i saw but i don't care how i was mine i wish that each reasons on the salt lakeline casey jones got another poppa my special time

why would you ever get it was so old are love yes you push you weak i'd keep it in my list and if there's what the way was mine oh you can hear

slow to me for the only way oh to the harp and his back but you've almost gonna before to fly all i need you listen we shall come on a him his child was mine the looked is on in the mouth make a blanket with my baby through a good little dream

G. Simple RNN - 80th epoch

so i won't clean up on the cry i'll find you a place when you're not low it's everything makes it

you are everything everything is you oh you are everything say i might like her thing when you find

now i'm standing inside outside which is the right side i'm standing the left side the flat earth december when your body you'll be and i'll get big broken bones that then the day seems always just want go on

i'd let it pass you on by a world i can't hide what's in here standing going alone a moment echoing yeah every gonna miss that he's see my little and you are singing

all the way of the side make room in here are world makes it crawl while get by now where i play her in the grou ou ou ound a travesty starin' at me ee

old glass houses ivory towers they flash like a sun and meet with fun just stop a blood above fadin' night if my boss finds through the crowd

no i'm it in the sky and i was cold my heart so melting or oh he's it in the way people will dat a man is a sigh

won't be the here that see with my lies i found you melt inside him i'm falling in your own baby to read it up

and the same not you begun every simple lies that it's they in a feather as i don't get paid oh pretty please was all alone

all within

the public enemy's the man that goes new acts blind searching in a girl of the basement holding the verdict is a heart that i could got a time to your heart i open his little just do to your phone

they never met with you babe how it's hard for me for the next train he can rock glass a left for the station and he stepped into the cabin my life seems so man go on the world

i'm just miles on a car just miles on a car i only need a map of where you are they'll never be right fun

when i was arrested i was dressed in black they put me on a train and they took my mind and he'll think you don't you no i tried on about them when they go out our hearts cryin' more love i know that's all we need know what we've seen

H. Simple RNN - 110th epoch

i don't need a calculator
to know i'm gonna see you later
and i don't need a secretary
so where the sun of alone
best things take love
if you're anywhere
made me one last kiss
and they're just miles on a car that
just up twenty in my time
but i only wish i get ever

you i love you i'm a liar so left me i let you go unselfishly 'cause everyone needs time

ktulu ktulu so bad if you want to hear with another day on your feet move it to the rhythm

just miles on a car i only need a map of where you are they'll never be a place that is too far and you and the change out it's me you got out i'd give to laugh i'm gonna go my pack is tonight i knew now you see driving you

you got that winging for your head shut your mouth but he went away the invader will split so they were at the right in which man and i got if i die flip flop and fly i don't care if i die don't ever leave me

I. LSTM (Hidden Layer) - 20th epoch

i might not know what love is but i know what it ain't

you are everything everything is you oh you are everything you're so f****n' special i wish i was special

but i'm a creep i'm a weirdo
what the hell am i doing here
the radio was his toy
was a beautiful day out in santa cruz
they were feelin' so good it shoulda been a crime
come all night to that memphis beat

i'm not looking back but i want to look around me now time stands still see more of the people and the places that surround me now

J. LSTM (Hidden Layer) - 50th epoch

i never knew the likes of you

extraordinary thing
you're all going to die down here
get out
that every day i just wanna give you
much more love
i'm warped and it was thing that a piece of sunshine
and there's a for sale sign on a little house
i saw just about a mile or so from here
but i've always been the kind for pullin' up the stakes
it's ain't never been like me to put down roots

you're too near me nasty boy girl me i'm gonna ever happen stand up and i'm back in the race nothing is going to stop me i wasn't born to fail i'm taking the inside rail

all the odds against me in the two horse race you're so won't know no ambition just existing sorrow breaks a good man down

i remember all the good times when the world was ours to flame then she left me took the sunshine every night wind speaks

her name can't stop loving can't stop living there's no answer to be

found

no ambition just existing sorrow breaks a good man down

i remember all the good times when the world was ours to flame then she left me took the sunshine every night wind speaks her name

K. LSTM (Hidden Layer) - 80th epoch

i name it exalted a restrained shaman

mother russia dance of the czars hold up your heads be proud of what you are now it has come freedom at last turning the tides of history and your past

mother russia dance of the czars hold up your heads be proud of what you are now it has come freedom at last turning the tides of history and your past

L. LSTM (Hidden Layer) - 110th epoch

i just can't go on livin' life as i do comparing each boy to you babe no no they just won't do

chorus
all you know versus all you don't
i know just find a gun
i'll give them a state a state of unconsciousness

retribution no solution constitution discrimination through the nation raining hatred

keep it in the family
i'm the thing that you most fear
i don't keep it in the family
don't even try to tell me what you think is right
when to you blacks are ni****s and jews are k***s
and you expect to be taken seriously
but your actions they're more than curiously
juvenile you emulate what you hate
you love me

and there's always something more that i should tell you more lost that i am found so i'm trying to clear my head so i'll be the box was cool and the band was prime they made it back up front to their seats just in time a place to hell for bait for a while

as i would tell you weh di ruggu ruggu use dat's what jr gong him use you're gonna laugh when you're down and out boy i'm gonna laugh when you're on that lonesome ride

back all the way to china in a police car from japan oh yeah sitting in the backseat crying where's your pride and slap yourself on the back before you tell me what you heard

M. Boney M.

time for me of all right sing a happy morning

all the people
'cause the people are leavin'
when the people believin'
they didn't get a lovers in the middle of the night
it's their out
but he ever how to you
he was a steppenwolf and with a smile she died

no no no one at all now ma ma ma ma baker she taught her four sons

by the rivers of babylon there we sat down ye eah we wept when we remembered zion all the way of angels o come let us adore him christ the lord sing choirs of angels music isn't somewhere they gathered all around him to see him and adore

this day will live forever oh my lord my lord he is a personation there came great jubilation la la de da la la de da all you gotta say is la de da

N. Artist 2

i am a fugitive being hunted down like game so we'll be in our way to kiss to be the one that will ends

can you see what they do they are grinding us down who are the fear of your need and night my blood where you see

i am a fugitive being hunted down like game but i am the chosen one i'm not a man i'm a dead time for my hand i'll be you i will know i'll give me back

i can't begin to understand the lies to run you're the same in my father and i'll be alright just a dream is inside

i feel they would chosen the woman we will have a done or that i heard it to me please tell me now what love is i'm not too born that i know what i want and i don't i know i'm not so there

when i can know what to know i'm gonna gonna let it on my hell i feel i hope that i like the chance to all the things that we cherish and love nothing left but to face this all on my own cause i am the chosen one

O. Sequential - (256, 1024) - 30th epoch, 200 lyrics

I'm gonna be ke when you sing along

With me block jaybird,

Why should you sacrifice

If you're not my enemy anymore

There's a hard habit to break

Such a hard habit to break

P. Sequential - (512, 1024) - 30th epoch, 200 lyrics

I'll be the goou under thas way a dream about me I'm yours 'til I die

So in love

So in love

So in love

So in love

I've got to go away?

If the sun should do

I drigiou don't old me close and hold me fartasy empty alone

Man, it's telling jokes In a nightclub

Pearl's a singer
She starts there was a time

She starts there was a time when you let me go (Let me go)

I don't know why you stay

'Cause you don't owe me nothing

But you give it to me "I'm farmain the baby please don't go

Cause if nobody hears that I rave.

The pony sty

The darktown surr that I wanted was yours,

Making my wart a feel of your bird

From California to London town.

I will hold it down,

I promise so baby please don't go

Cause if nobody hears that tree fall down,

Does it make a sound?

And am I even here if I'm alone

And there's nothing, I can broke my heart, but what of

it

Say, its only a carvas look into her faces

The one light

I see la vie en rose

When you kiss my ways it blows

Everybody knows that the dou

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